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Status of the Woodland Caribou (*Rangifer tarandus caribou*) in Alberta:

Update 2010

Alberta Wildlife Status Report No. 30 (Update 2010)

Alberta Conservation Association

Government of Alberta

Status of the Woodland Caribou (*Rangifer tarandus caribou*) in Alberta:

Update 2010

Prepared for:
Alberta Sustainable Resource Development (ASRD)
Alberta Conservation Association (ACA)

Update prepared by:
Deborah Cichowski

Much of the original work contained in the report was prepared by Elston Dzus in 2001.

This report has been reviewed, revised, and edited prior to publication.
It is an ASRD/ACA working document that will be revised and updated periodically.

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PREFACE

Every five years, the Fish and Wildlife Division of Alberta Sustainable Resource Development reviews the general status of wildlife species in Alberta. These overviews, which have been conducted in 1991 (*The Status of Alberta Wildlife*), 1996 (*The Status of Alberta Wildlife*), 2000 (*The General Status of Alberta Wild Species 2000*), and 2005 (*The General Status of Alberta Wild Species 2005*) assign individual species "ranks" that reflect the perceived level of risk to populations that occur in the province. Such designations are determined from extensive consultations with professional and amateur biologists, and from a variety of readily available sources of population data. A key objective of these reviews is to identify species that may be considered for more detailed status determinations.

The Alberta Wildlife Status Report Series is an extension of the general status exercise, and provides comprehensive current summaries of the biological status of selected wildlife species in Alberta. Priority is given to species that are *At Risk* or *May Be At Risk* in the province, that are of uncertain status (*Undetermined*), or that are considered to be at risk at a national level by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Reports in this series are published and distributed by the Alberta Conservation Association and the Fish and Wildlife Division of Alberta Sustainable Resource Development. They are intended to provide detailed and up-to-date information that will be useful to resource professionals for managing populations of species and their habitats in the province. The reports are also designed to provide current information that will assist Alberta's Endangered Species Conservation Committee in identifying species that may be formally designated as *Endangered* or *Threatened* under Alberta's *Wildlife Act*. To achieve these goals, the reports have been authored and/or reviewed by individuals with unique local expertise in the biology and management of each species.

EXECUTIVE SUMMARY

Woodland caribou (*Rangifer tarandus caribou*) in Alberta are currently designated as *Threatened* under Alberta's *Wildlife Act*. Initially listed as *Endangered* in 1987, because there was no *Threatened* category at that time, the woodland caribou was subsequently listed as *Threatened* in 1997. The *Threatened* status was assigned because of reduced distribution, declines in the number and size of provincial caribou populations, and threats of continued declines associated with human activities. This report updates the first edition of the Alberta woodland caribou status report that was completed in 2001, and is provided to assist in re-evaluating the status of woodland caribou in Alberta.

All woodland caribou in Alberta belong to either the Boreal or Southern Mountain woodland caribou populations, both of which have been delineated across Canada and recommended as *Threatened* nationally by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). These recommendations were accepted by the federal Minister of Environment, and have led to the two national caribou populations being listed as *Threatened* under Canada's *Species at Risk Act* (SARA).

Woodland caribou require large tracts of relatively low-productivity mature to old conifer forests and forested peatlands, which contain lichens, the primary winter food source for caribou. Under natural conditions, the forests used by woodland caribou typically support relatively few other ungulates and as a result support few wolves; predation by wolves is the primary cause of woodland caribou death. Through their adaptation to these types of habitats, under natural conditions woodland caribou are able to spatially separate themselves from other prey species and thereby reduce the risk of predation by wolves. A considerable body of published (peer reviewed) research indicates that ongoing caribou population declines in Alberta are a result of habitat alteration associated with human activities and in some cases forest fires, which have led to excessive predation of caribou by wolves.

There has been extensive monitoring of woodland caribou populations and habitats in Alberta over the last 20 years; Alberta is a leading jurisdiction in Canada with regard to woodland caribou monitoring. In addition, there has been a large amount of recent research conducted in Alberta and elsewhere on woodland caribou, particularly with respect to effects of industrial and other human activities on caribou populations and habitats.

Woodland caribou in Alberta have experienced significant declines in both number and distribution since 1900. Sixteen woodland caribou populations now remain in the province; adequate population monitoring data are available for 13 of these populations. Of the 13 populations with sufficient monitoring data, 10 are demonstrating population decline. The 10 caribou populations documented to be in decline occupy 83% of the total area of current caribou range in Alberta, and constitute the majority of caribou occurring in the province. Considering current estimates of caribou population sizes, approximately 70% of all caribou in Alberta occur in populations that are known to be declining. Declines are evident across the province and affect caribou populations in both the Boreal and Southern Mountain areas. More provincial caribou populations are now in sustained population decline than was the case when the first edition of

this status document was prepared in 2001. In addition, the Banff caribou population is believed to have been extirpated in 2009.

The Little Smoky and possibly the A La Peche caribou populations (together occupying 6% of current caribou range in Alberta, and composing approximately 8% of all caribou in the province) are currently being kept stable, at reduced population levels, by means of a program to annually reduce wolf abundance.

Based on two years of data, the Yates caribou population (occupying 3% of current caribou range in Alberta, and constituting approximately 12% of all caribou in the province) appears to be stable. This is the only monitored population in the province that is demonstrating population stability in the absence of predator management.

All provincial caribou populations are believed to be small in size and entirely or largely isolated from other caribou populations. Caribou ranges are continuing to recede.

Levels of habitat alteration from industrial developments are high on most caribou ranges in the province and projections forecast continued high levels of future industrial activity. In addition, forest fires have affected habitat in some ranges. Provincial land-use guidelines for industrial activities have not succeeded (as a sole tool) in providing for long-term caribou population and habitat conservation, and guidelines for caribou habitat protection currently are not being applied in all caribou ranges within the province.

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For the original 2001 report prepared by Elston Dzus:
Contributors denoted with an asterisk (*) provided information used in the first edition for describing the national range or jurisdictional status of woodland caribou. The following individuals are listed alphabetically but deserve equal consideration: Ted Armstrong* (Ontario Ministry of Natural Resources); Rhys Beaulieu (Saskatchewan Environment and Resource Management); Kent Brown (Terrestrial & Aquatic Environmental Managers Ltd.); Stan Boutin (University of Alberta); Gordon Court (Alberta Natural Resources Service); Rehaume Courtois (Quebec); Doug Culbert (Alberta Natural Resources Service); Christine Doucett* (Newfoundland); Rick Farnell* (Yukon Territorial Government); Christine Found (Alberta Natural Resources Service); Mike Flannigan; Anne Gunn (Northwest Territories); Mark Heckbert (Alberta Natural Resources Service); Doug Heard (B.C. Environment, Wildlife Branch); Gerry Kuzyk (University of Alberta); Dave Laing (Alberta Lands and Forest Service); Ron Larche* (Manitoba Natural Resources); Ken Lowe (Alberta Lands and Forest Service); Gerry Lynch (independent ecologist); Mike Norton (formerly Alberta Conservation Association); Emma Pharo (formerly University of Alberta); Ken Rebizant (Manitoba Natural Resources); Christoph Rohner (University of Alberta); Gerry Samide (Samide Engineering Ltd.); Ian Thompson; Tim Trottier (Saskatchewan Environment and Resource Management; Dale Vitt (University of Alberta); and Ralph Woods (Alberta Lands and Forest Service). In addition, support was provided by the multitude of researchers and supporting agencies associated with the Alberta Boreal Caribou Committee.

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For the 2010 update prepared by Deborah Cichowski:
For this second edition of the woodland caribou status report, recent data, analyses, and maps have largely been obtained from the Fish and Wildlife Division of Alberta Sustainable Resource Development (ASRD), the multi-stakeholder Alberta Caribou Committee, and from Environment Canada. In addition, this second edition draws updated information from recent papers published in scientific journals and from various unpublished reports.

Global positioning system (GPS) radio telemetry location information for woodland caribou was provided by Alberta Caribou Committee, Fish and Wildlife Division of ASRD, Alberta-Pacific Forest Industries Inc., Alberta Plywood Ltd. (Slave Lake), Fiona Schmiegelow (Department of Renewable Resources, University of Alberta), Government of the Northwest Territories (Dept. Environment and Natural Resources), Manning Diversified Forest Products Ltd. (Manning), Mark Hebblewhite (College of Forestry and Conservation, University of Montana), Parks Canada, Vanderwell Contractors (1971) Ltd. (Slave Lake), and Weyerhaeuser Company.

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INTRODUCTION

A considerable amount of research and monitoring has been conducted on woodland caribou populations and habitats in Alberta since the first edition of this status report (Dzus 2001) was published. In addition, there are new research and other reports available for woodland caribou from outside of Alberta. This second edition of *The Status of the Woodland Caribou (Rangifer tarandus caribou) in Alberta* builds on and updates information presented in the first edition.

Caribou (*Rangifer tarandus*) are currently found in all Canadian provinces and territories except for Prince Edward Island, Nova Scotia and New Brunswick, from where they have been extirpated. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has assessed and designated several broad geographic categories or populations of woodland caribou in Canada based on taxonomy (Banfield 1961), the National Ecological Areas adopted by COSEWIC in 1994, and genetic and ecological information (Thomas and Gray 2002). The woodland subspecies (*R. t. caribou*) occurs almost exclusively in Canada, and is distributed across various forested and mountainous regions of the country, including parts of northern and west-central Alberta. All woodland caribou in Alberta belong to either the nationally defined Boreal or Southern Mountain populations (Figure 1), both of which have been designated as *Threatened*[1] by the COSEWIC (COSEWIC 2009a), and also listed as *Threatened* under Canada's *Species at Risk Act* (SARA).

The status of other woodland caribou populations in Canada includes *Not at Risk* for the Newfoundland population, *Special Concern* for the Northern Mountain population, and *Endangered* for the Atlantic-Gaspésie population (COSEWIC 2009a).

Under the Government of Alberta general wildlife status process, woodland caribou have been determined to be *At Risk* in the province (Alberta Sustainable Resource Development 2007). Woodland caribou were listed as *Endangered* in 1987 (the category of *Threatened* did not exist under Alberta's *Wildlife Act* at that time); this status was adjusted to *Threatened* in 1997 once that species at risk category was created. The *Threatened* status of woodland caribou under Alberta's *Wildlife Act* was reconfirmed following a review in 2001.

Ecotypes (forms of a given species with characteristic adaptations) are frequently used in the description of caribou (Edmonds 1991, Thomas and Gray 2002) because of the tremendous variation in behaviour, habitat use patterns, and/or morphology of caribou from different regions and ecological conditions. In this document, woodland caribou that live year-round in forested habitat will be referred to as boreal ecotype, whereas caribou that winter in forested foothills and migrate to alpine habitat in the Rocky Mountains during summer will be referred to as mountain ecotype (see Edmonds 1991), in accordance with the COSEWIC designations.

DISTRIBUTION

1. Alberta - Despite significant declines in the distribution and abundance of woodland caribou in Alberta since 1900, woodland caribou currently remain in some parts of west-central Alberta along the Rocky Mountains and nearby foothills, and in portions of the boreal forest in northern Alberta; in total, 16 populations remain (Figure 2). Eleven boreal ecotype caribou populations remain in northern regions of the province[2]. Five caribou

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[1] See Appendix 1 for definitions of selected status designations.

[2] Note: the formerly described Deadwood and Hotchkiss caribou populations are now considered to be components of the Chinchaga caribou population.

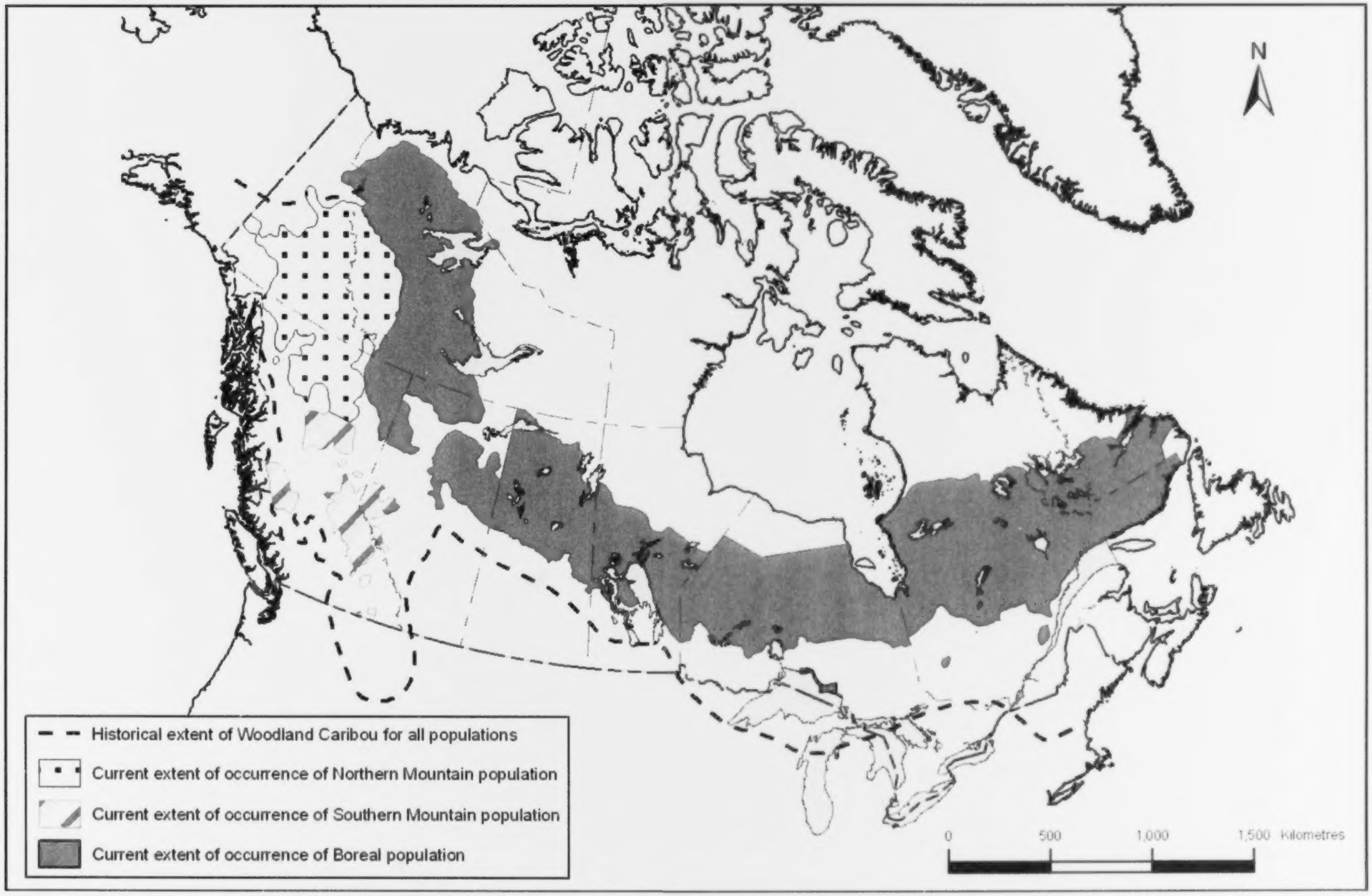
N
Historical extent of Woodland Caribou for all populations
Current extent of occurrence of Northern Mountain population
Current extent of occurrence of Southern Mountain population
Current extent of occurrence of Boreal population
0
500
1,000
1,500 Kilometres

Figure 1. The approximate current and historical distribution (extent of occurrence) of woodland caribou (*Rangifer tarandus caribou*) in North America (from Environment Canada 2007).

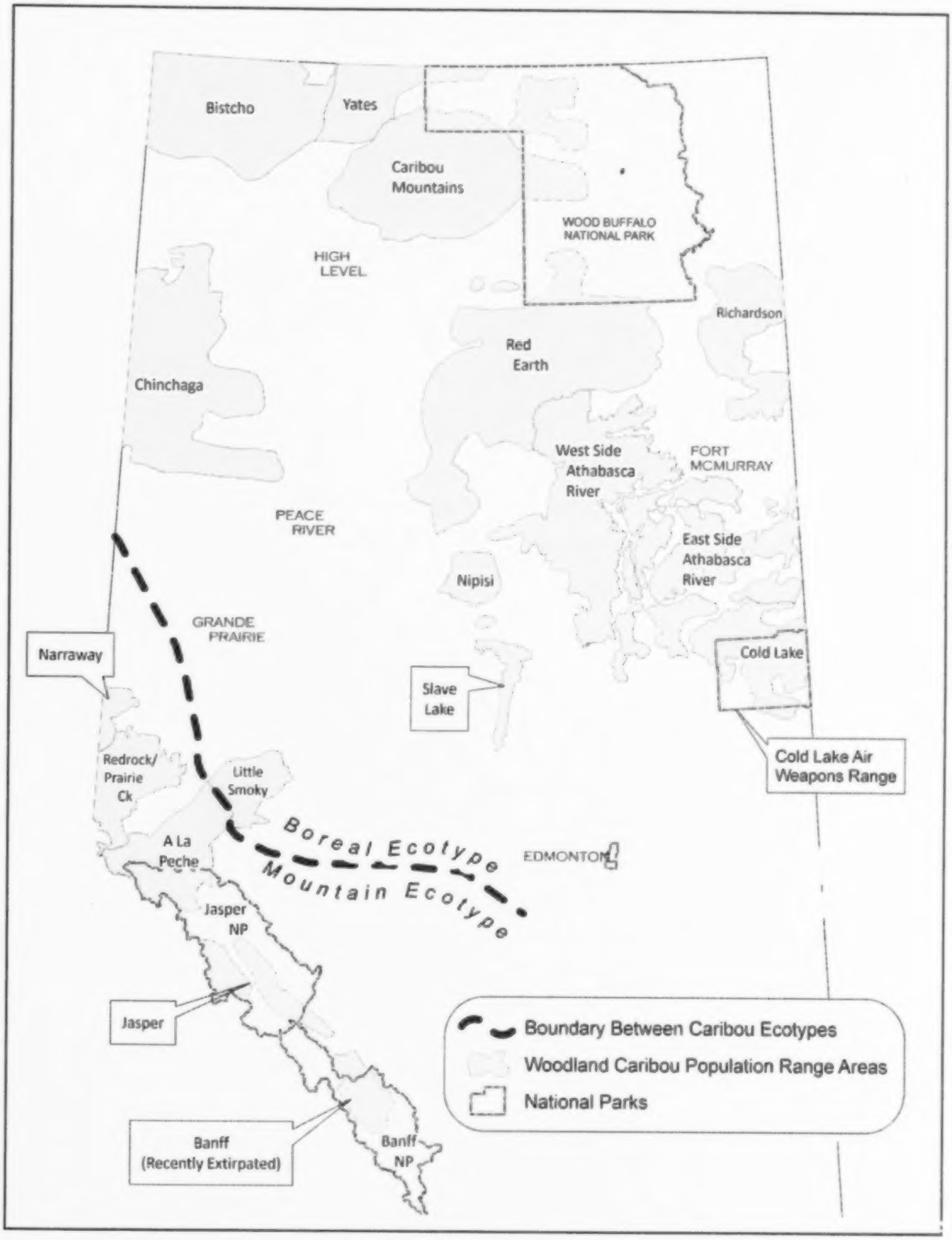

Figure 2. Woodland caribou population names and approximate current range areas in Alberta.

populations occur in west-central Alberta: four mountain ecotype populations, and one boreal ecotype population. The Banff mountain ecotype population was recently extirpated; the last five known caribou from this population died in 2009 (A. Dibb and J. Whittington pers. comm.).

Since 1993/94, when detailed monitoring of caribou population growth (see below; *Population Size and Trend*) began in the province, caribou in the East Side of Athabasca River area have been treated as a single population occupying one range area. This lumping of populations occurred as a convenience and in relation to a lack of knowledge at the onset of monitoring activities. The East Side of Athabasca River range, however, is now known to contain seven small populations of caribou that are largely independent from each other (Figure 3). Similarly, the Jasper caribou population is known to be composed of three essentially separate groups of caribou (Figure 4).

The range areas occupied by individual caribou populations have been delineated based on up to 35 years of caribou sightings (Figure 5), very high frequency (VHF) radio-telemetry (Figure 6) and global positioning system (GPS) radio-telemetry (Figure 7) data, local knowledge, and biophysical analyses. Defining habitat through biophysical analyses is probably the best approach for building maps showing the potential distribution of woodland caribou in Alberta (Bradshaw et al. 1995); this approach could also provide insight into the historical distribution of woodland caribou in the province. Recently, Environment Canada completed an analysis to understand the potential distribution of boreal ecotype woodland caribou in Canada (Environment Canada 2008).

The current extent of occurrence of woodland caribou in Alberta (based on the identified caribou range areas) is estimated to be approximately 134 833 km^2, with 118 535 km^2 in boreal ecotype caribou ranges and 16 298 km^2 in mountain ecotype caribou ranges (Table 1). Table 1 also provides the extent of natural subregions found within each caribou range.

Currently, woodland caribou populations in Alberta are largely separate and non-intermixing. Global positioning system (GPS) radio collars applied to adult female caribou in recent years has demonstrated very little movement of animals between caribou ranges (Table 2). Female caribou range-use patterns and fidelity are essentially very traditional and confined to individual caribou range areas. This limits the possibility of caribou range re-occupation following extirpation of individual caribou populations. Less is known about the movements of male caribou. Information available when the 2001 status report was prepared (see Appendix 2 in Dzus 2001) indicated that during up to 18 years (depending on caribou range) of caribou VHF radio collaring work, only one seasonal movement by a radio-collared male caribou was recorded between the four caribou ranges in west-central Alberta outside of the national parks. In addition, all west-central populations are known to have geographically separate breeding areas. The first edition of this status report also described that during 10 years of VHF radio collaring work in northern Alberta, only limited movements were recorded for radio-collared female caribou across the Athabasca River (see Appendix 2 in Dzus 2001); otherwise, all caribou ranges in northern Alberta appeared to contain separate and non-intermixing caribou populations.

Some Alberta woodland caribou ranges cross jurisdictional boundaries. In west-central Alberta, the Narraway population winters in lower elevation forests in Alberta and adjacent British Columbia, but migrates to Rocky Mountain summer ranges entirely within British Columbia. The summer range of the Redrock-Prairie Creek population occurs in both Alberta and British Columbia. The summer range of the A La Peche population is largely in Alberta, with

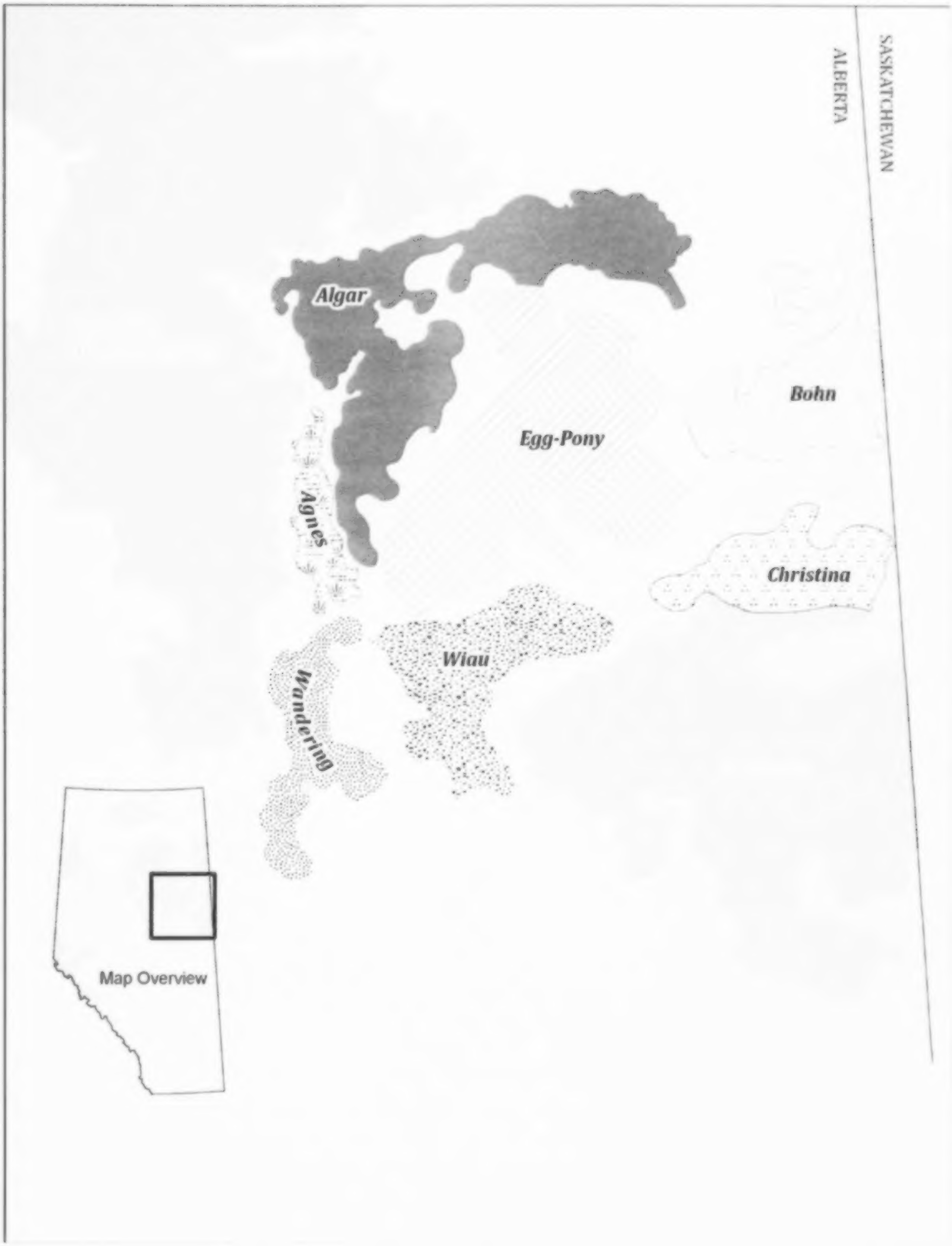

Figure 3. Names (bold text) and approximate current range areas for seven woodland caribou populations contained within the East Side Athabasca River area in Alberta.

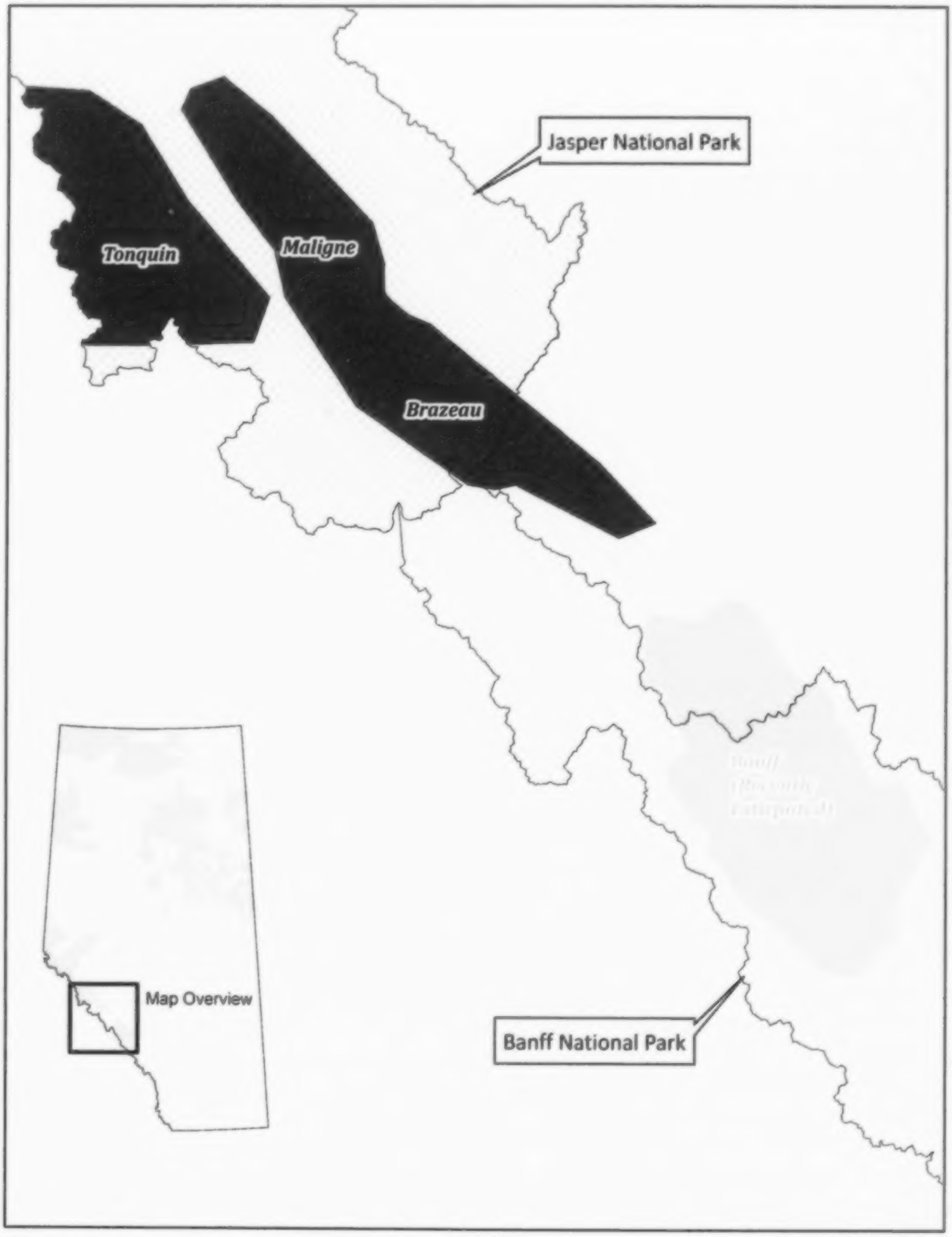

Figure 4. Names (bold text) and approximate current range areas for three separate groups of woodland caribou (termed subpopulations by Parks Canada) that compose the Jasper caribou population.

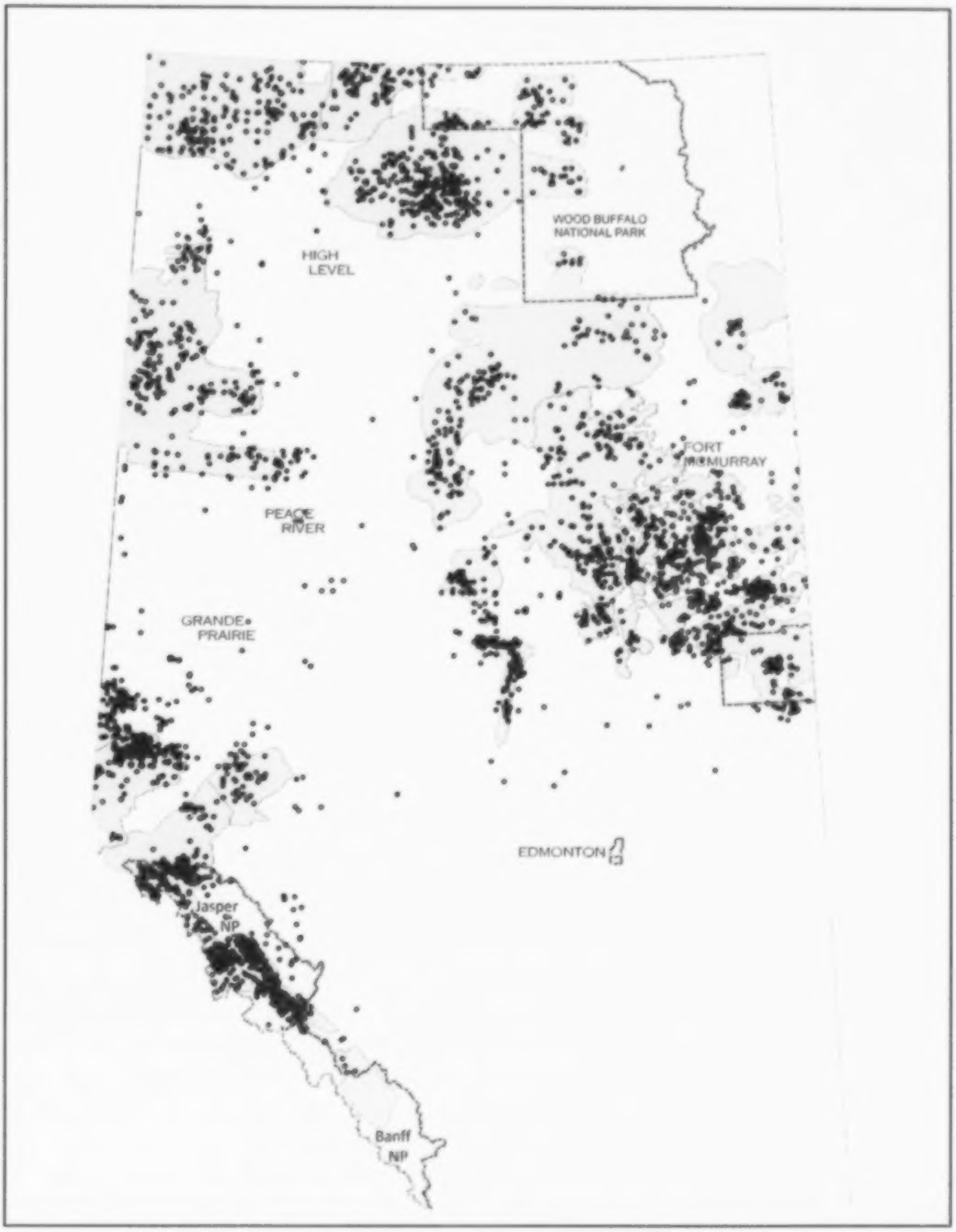

Figure 5. Non-telemetry-based observations (i.e., sightings) of caribou in relation to caribou range areas in Alberta. Data are from various sources collected between 1955 and 2009 (n = 8167). Note: Figure does not include all recorded observations, and primarily consists of observations made since 1980.

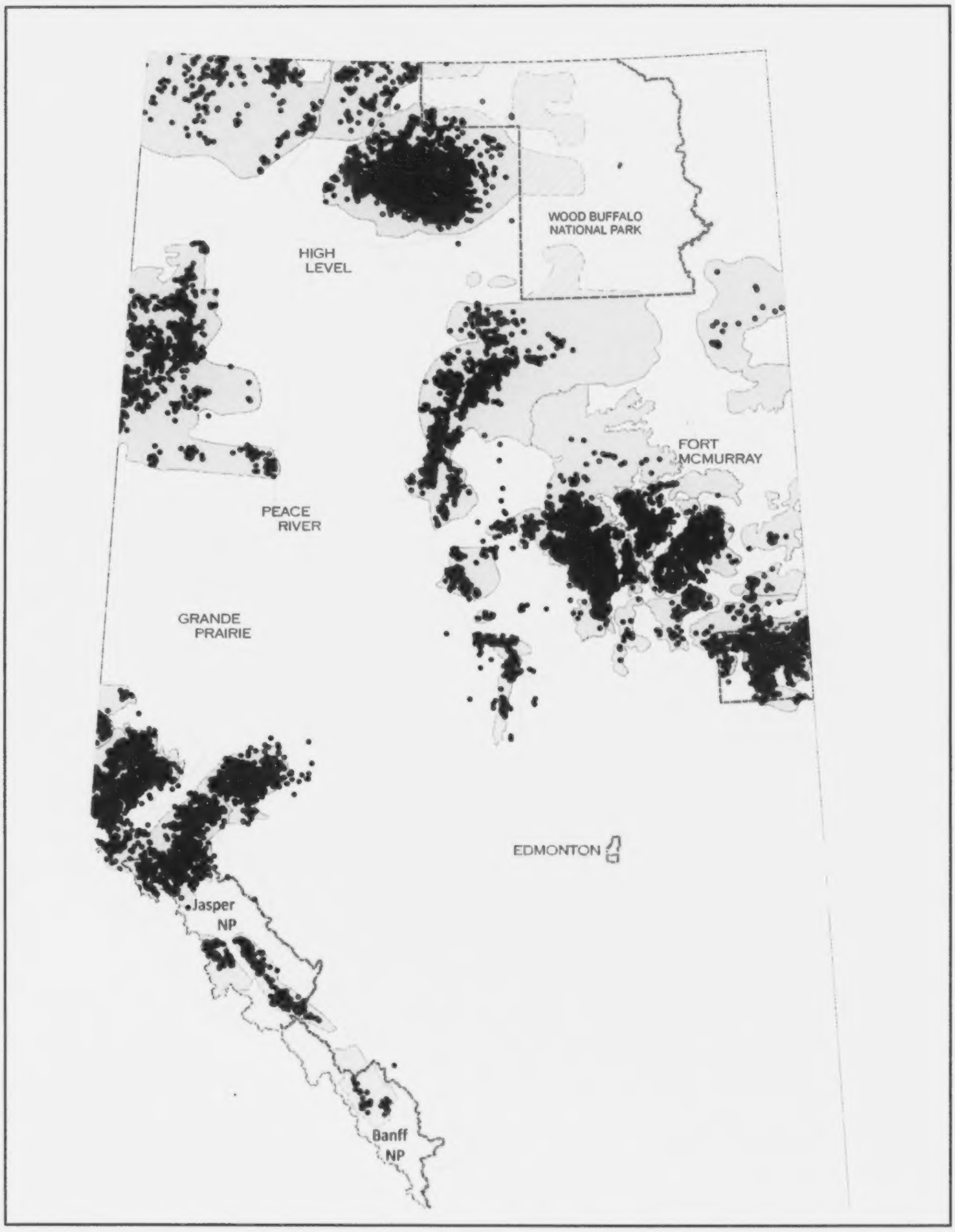

Figure 6. Very high frequency (VHF) radio-telemetry locations of collared caribou in relation to caribou range areas in Alberta between 1980 and 2009 (n = 36 733).

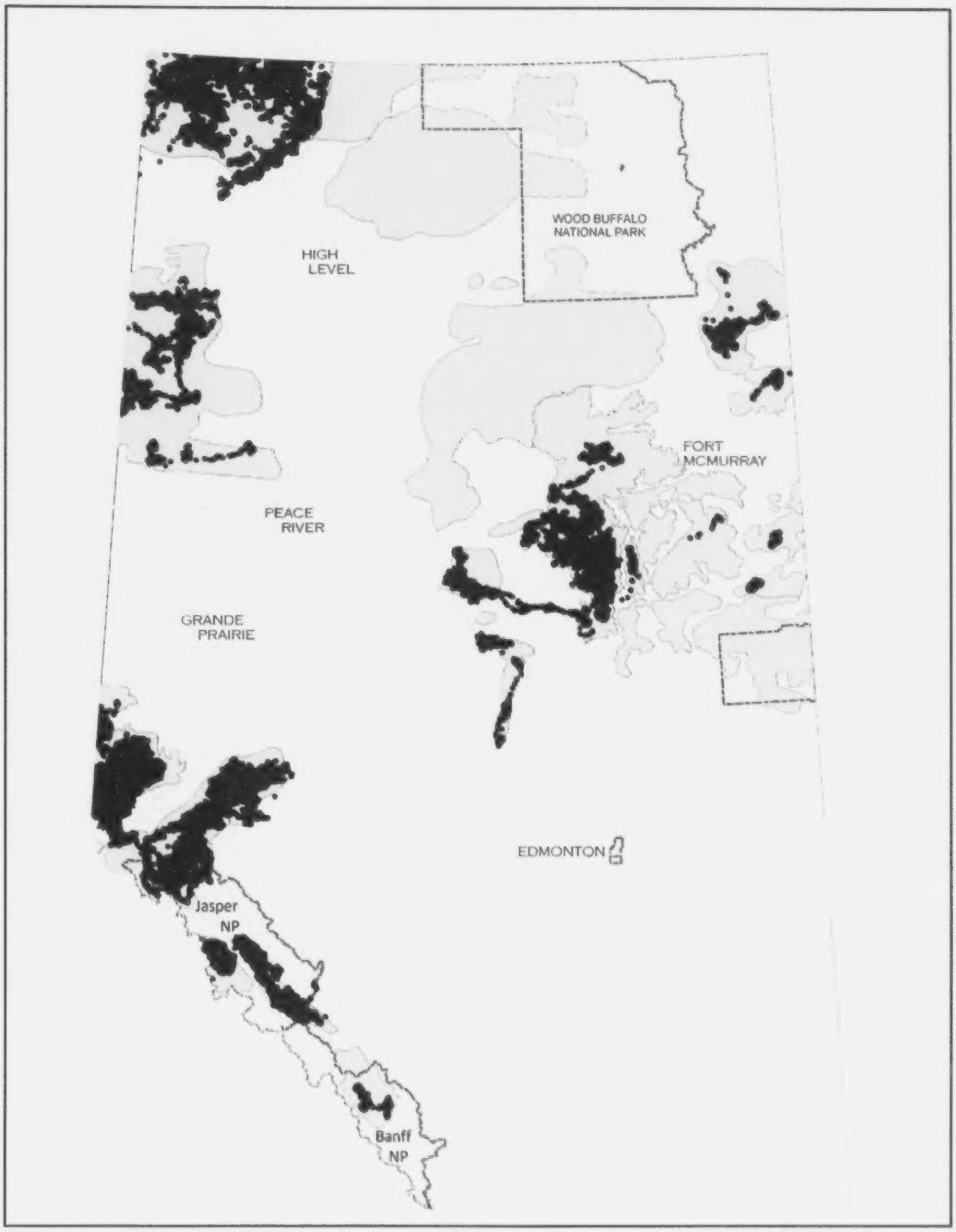

Figure 7. Global positioning system (GPS) radio-telemetry locations of collared caribou in relation to caribou range areas in Alberta between 1998 and 2009 (n = 843 473).

Table 1. Size of woodland caribou range areas (extent of occurrence) in Alberta, and extent of natural subregions[1] within each range.

Caribou Range (ecotype)	Natural Subregion	Area (km^2)
Mountain ecotype:		
Narraway	Central Mixedwood	75
	Lower Foothills	574
	Subalpine	59
	Upper Foothills	533
	Total range area	**1 241**
Redrock-Prairie Creek	Alpine	335
	Lower Foothills	141
	Montane	4
	Subalpine	3 004
	Upper Foothills	1 032
	Total range area	**4 516**
A La Peche	Alpine	1 900
	Subalpine	3 038
	Upper Foothills	765
	Total range area	**5 703**
Jasper	Alpine	2 768
	Montane	49
	Subalpine	2 021
	Total range area	**4 838**
Banff (recently extirpated)	Alpine	1 601
	Montane	45
	Subalpine	616
	Total range area	**2 262**
Mountain ecotype range total (excluding Banff)		**16 298**

Boreal ecotype:		
Bistcho	Boreal Subarctic	2 195
	Central Mixedwood	367
	Lower Boreal Highlands	2 854
	Northern Mixedwood	7 851
	Total range area	**13 267**
Yates	Northern Mixedwood	4 489
	Total range area	**4 489**
Caribou Mountains	Boreal Subarctic	9 325
	Central Mixedwood	1 660
	Lower Boreal Highlands	3 656
	Northern Mixedwood	687
	Total range area	**15 328**

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[1] From: 2005 Natural Regions and Subregions of Alberta (http://tprc.alberta.ca/parks/heritageinfocentre/naturalregions/default.asp)

Table 1 continued:

Caribou Range (ecotype)	Natural Subregion	Area (km^2)
Chinchaga	Central Mixedwood	405
	Dry Mixedwood	309
	Lower Boreal Highlands	12 795
	Upper Boreal Highlands	4 008
	Total range area	**17 517**
Slave Lake	Central Mixedwood	1 337
	Lower Foothills	160
	Total range area	**1 497**
Nipisi	Central Mixedwood	1 915
	Total range area	**1 915**
Red Earth	Central Mixedwood	12 644
	Lower Boreal Highlands	4 624
	Upper Boreal Highlands	2 709
	Total range area	**19 977**
West Side Athabasca River	Central Mixedwood	13 191
	Lower Boreal Highlands	1 025
	Lower Foothills	53
	Upper Boreal Highlands	741
	Total range area	**15 010**
East Side Athabasca River	Central Mixedwood	10 407
	Lower Boreal Highlands	4 117
	Total range area	**14 524**
Cold Lake	Central Mixedwood	5 538
	Total range area	**5 538**
Richardson	Athabasca Plain	4 325
	Central Mixedwood	2 188
	Kazan Uplands	33
	Total range area	**6 546**
Little Smoky	Lower Foothills	365
	Subalpine	123
	Upper Foothills	2 439
	Total range area	**2 927**
Boreal ecotype range total:		**118 535**
Total for Alberta:		**134 833**

Table 2. Summary of adult female caribou movements between Alberta caribou ranges from global positioning system (GPS) radio-telemetry collar location data.

Caribou population	**Number of collars deployed (period of GPS-collar deployment)**	**Number of caribou with movements >1 km into other caribou ranges (% total caribou)**	**Average number of monitoring days per collar (range of days)**	**Total number of caribou locations[1]**	**Total number of caribou locations in other caribou ranges (% total locations)**
West Side Athabasca River	35 (1998-2000)	0	358 (89-699)	114 650	0 (0%)
East Side Athabasca River (Egg-Pony)	1 (2008)	0	41 (N/A)	245	0 (0%)
East Side Athabasca River (Christina)	2 (2009)	0	56 (56-56)	672	0 (0%)
East Side Athabasca River (Bohn)	3 (2009)	0	90 (25-122)	1 616	0 (0%)
Bistcho	40 (2006-2009)	0	657 (115-1136)	51 215	0 (0%)
Chinchaga	16 (2007-2009)	0	307 (22-643)	59 658	0 (0%)
Slave Lake	5 (2006-2007)	0	500 (141-595)	58 741	0 (0%)
Nipisi	2 (2006-2008)	1	463 (331-595)	18 201	808 (4.4%)[2]
Richardson	11 (2008-2009)	0	110 (58-183)	7 257	0 (0%)
Little Smoky	41 (1999-2009)	0	355 (34-738)	95 135	0 (0%)
Redrock-Prairie Creek	71 (1998-2009)	1	358 (22-851)	181 448	204 (0.1%)[3]
A La Peche	23 (2002-2009)	1	476 (75-780)	97 739	802 (0.8%)[4]
Narraway	38 (2001-2009)	1	480 (24-789)	90 051	6 (0.007 %)[5]
Jasper	45 (2002-2009)	0	254 (9-617)	160 705	0 (0%)
Banff	2 (2003-2005)	0	519 (380-657)	5 821	0 (0%)
Total	**335 (1998-2009)**	**4 (1.2%)**		**943 154**	**1820 (0.2%)**

[1] Includes GPS location points from British Columbia and the Northwest Territories (for cross-boundary caribou populations).
[2] Composes 5.7% of the 14 258 total locations for the individual caribou.
[3] Composes 17.3% of the 1179 total locations for the individual caribou.
[4] Composes 10.5% of the 7668 total locations for the individual caribou.
[5] Composes 0.1% of the 4210 total locations for the individual caribou.

a very minor extension into British Columbia. For the last several decades the Jasper caribou population has been largely confined year-round to mountainous areas within the national parks and immediately adjacent British Columbia; this population and the extirpated Banff population formerly demonstrated typical mountain ecotype migratory behaviour and migrated to lower elevation forested winter areas in the foothills east of the national parks (Fish and Wildlife Division unpubl. data and report). In northwestern Alberta, the Chinchaga population extends into British Columbia, the Bistcho population occupies a range extending into British Columbia and the Northwest Territories, and the Yates population extends into the Northwest Territories. The Yates, Caribou Mountains and Red Earth caribou populations extend somewhat into Wood Buffalo National Park, although relatively few data are available for caribou within the park (R. Kindopp pers. comm.). In northeastern Alberta, the Cold Lake caribou population occurs within the federally controlled Cold Lake Air Weapons Range; this population also ranges into Saskatchewan.

The current distribution of woodland caribou in Alberta has declined relative to its historical distribution. Although a detailed description of historical caribou distribution in northern Alberta is not available, Soper (1964) described the former range of woodland caribou in the northern part of the province as the "whole of northern Alberta south to the lower limits of mixed-wood forest (approximately Cold Lake; Lac la Biche; Barrhead) and south in comparable, western environment to about the latitude of Sundre; now absent in the major part of that region." Edmonds and Bloomfield (1984) reviewed historical records of caribou distribution in west-central Alberta and documented that caribou have disappeared, or only remain as fragmented remnant populations, in many parts of the Rocky Mountains of Alberta (see also Soper 1970).

In recent years, caribou range recession and loss has been observed to continue (Fish and Wildlife Division unpubl. data), including in the vicinity of Nordegg; near Rock Lake; portions of the Little Smoky, A La Peche, Redrock-Prairie Creek, and Narraway ranges; the Red Willow range, which formerly extended into Alberta but has now retracted into British Columbia; portions of the Chinchaga range, including Clear Hills and Deadwood; and Slave Lake. Caribou are believed to have been extirpated from the Banff caribou range in 2009.

Despite documented historical and ongoing range recession, woodland caribou were likely not as uniformly distributed as implied by Soper (1964). Current knowledge of habitat use and ecological conditions indicates that populations would have occurred in association with appropriate habitat. Some studies support the idea that caribou ranges have been relatively isolated for a long time. McLoughlin et al. (2004) suggested genetic differences in caribou in northern Alberta, with discrete genetic types bisected by the Peace River. Detailed genetic analysis in west-central Alberta demonstrated differences between the boreal ecotype Little Smoky population and adjacent mountain caribou populations (McDevitt et al. 2009).

2. Other Areas - The distribution of woodland caribou in North America has receded northward since the onset of European settlement (Figure 1; Bergerud 1974, Cumming and Beange 1993, Schaefer 2003, Soper 1964, Thomas and Gray 2002). The southern limit of woodland caribou distribution east of the Rocky Mountains historically followed the boreal forest, south into the Canadian Maritimes and the northeastern United States (Maine, Minnesota, Michigan, New Hampshire, Vermont, Wisconsin; U. S. Fish and Wildlife Service 1998). The northward contraction of woodland caribou range has been most extensive in eastern Canada (Bergerud 1974, Crête et al. 1994, Cumming and Beange 1993, Thomas and Gray 2002, Vors et al. 2007). Woodland caribou currently occur across

Canada, extending north into the Northwest Territories, Yukon and Alaska, and south into Washington and Idaho. Caribou require certain habitats, which may not be found throughout the broad extent of occurrence depicted in Figure 1; for simplicity, the distribution of caribou is shown as continuous.

Descriptions of current woodland caribou distribution across Canada vary in detail. Some provincial and territorial jurisdictions have developed precise caribou population range boundaries, whereas other jurisdictions depict broad areas of woodland caribou occupancy while they continue to collect field data to understand caribou range areas at finer scales (e.g., Environment Canada 2008). Currently, in Canada there are 57 recognized boreal caribou populations (Environment Canada 2008) and 35 recognized southern mountain populations[3] (Figure 2; Hatter 2006, British Columbia Ministry of Environment unpubl. data).

The former Dawson population on the Queen Charlotte Islands became extirpated by the 1920s (Thomas and Gray 2002). Woodland caribou were extirpated from Prince Edward Island before 1874, from New Brunswick by 1927 and from Nova Scotia by 1925 (Banfield 1974, Miller 1993).

HABITAT

Woodland caribou are a forest interior species that is strongly associated, at both home range and regional scales, with large tracts of mature to old, low productivity, upland and peatland conifer-dominated forests (Bradshaw et al. 1995, Dalerum et al. 2007, Environment Canada 2007, Fuller and Keith 1981, James et al. 2004, McLoughlin et al. 2005, Neufeld 2006, Saher 2005, Saher and Schmiegelow 2005, Schneider et al. 2000, Shepherd et al. 2007, Stuart-Smith et al. 1997, Szkorupa 2002, Tracz 2005). Mature to old, low productivity forests have the functional and physical habitat characteristics that woodland caribou require to survive, reproduce, disperse, and persist (Environment Canada 2007; also see Caughley and Gunn 1996). In particular, woodland caribou persistence can be attributed to their use of large intact habitat areas as spatial refuges from predation (Bergerud 1988, Bergerud and Page 1987, Cumming et al. 1996, Ferguson et al. 1988, James et al. 2004, Racey and Arsenault 2007, Rettie and Messier 1998, Seip 1992).

Caribou tend to avoid and distance themselves from river valleys, young forests, and more productive forests (Bradshaw et al. 1995, Dalerum et al. 2007, Fuller and Keith 1981, James et al. 2004, McLoughlin et al. 2005, Neufeld 2006, Oberg 2001, Stuart-Smith et al. 1997, Schneider et al. 2000, Tracz 2005). This helps to spatially segregate caribou from moose (*Alces alces*), deer (*Odocoileus* sp.), elk (*Cervus elaphus*) and wolves (*Canis lupus*), which tend to select river valleys, young forests, and more productive forests (James et al. 2004, Kuzyk et al. 2004, Neufeld 2006, Potvin et al. 2005, Rempel et al. 1997, Schwartz and Franzmann 1989).

The mature to old forests and peatlands selected by woodland caribou typically contain the caribou's primary winter food—lichens. Lichens are important forage for caribou and thus influence their habitat use and distribution. Lichens grow slowly (Scotter 1963) and are poor competitors against plants (Johnson 1978); they are generally more abundant in mature to older, low productivity forests, contributing to the affinity of woodland caribou for these types of forests (Bjorge 1984, Dunford et al. 2006, Kranrod 1996, Shepherd et al. 2007, Stepaniuk 1997).

Mountain and boreal ecotypes of woodland caribou differ in their seasonal movement and habitat use patterns. Mountain caribou in west-central Alberta are typically migratory and make seasonal migrations between alpine or subalpine summer range (in both Alberta and adjacent British Columbia) and lower elevation forested foothills winter range (Brown and Hobson 1998, Edmonds and Bloomfield 1984). Boreal ecotype animals wander extensively throughout the year, but typically show considerable overlap between winter and summer ranges (Hornbeck and Moyles 1995, Stuart-Smith et al. 1997).

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[3] Note: The government of British Columbia describes some groups of caribou in the Southern Mountains National Ecological Area as subpopulations. See Hatter 2006.

1. Boreal Ecotype Caribou **-** Alberta's boreal ecotype caribou are typically found throughout the year in forested peatland complexes dominated by black spruce (*Picea mariana*), larch (*Larix laricina*) and pine (*Pinus* sp.), and in upland pine forests (e.g., Anderson 1999, Bradshaw et al. 1995, Edmonds and Bloomfield 1984, Fuller and Keith 1981, Hornbeck and Moyles 1995). Caribou movements in northeastern Alberta were shown to be largely constrained by the boundaries of forested peatland complexes (Stuart-Smith et al. 1997). This pattern of lowland habitat use, in combination with use of lichen-rich upland stands of jack pine (*Pinus banksiana*) or lodgepole pine (*P. contorta*) is common to caribou in non-mountainous areas (Darby and Pruitt Jr. 1984, Rettie and Messier 2000, Schaefer and Pruitt Jr. 1991, Schneider et al. 2000). Research in north-central Alberta has shown that even in areas where small peatlands are interspersed in an upland matrix, caribou select treed bogs and fens (Anderson 1999, Boreal Caribou Research Program 1998, Boreal Caribou Research Program 1999a, James et al. 2004, Morton and Wynes 1997). More productive upland stands of trembling aspen (*Populus tremuloides*), white spruce (*Picea glauca*), paper birch (*Betula papyrifera*) and balsam fir (*Abies balsamea*) are seldom used or are avoided (Bradshaw et al. 1995, Fuller and Keith 1981, James et al. 2004).

Unlike barren-ground caribou (*R. t. groenlandicus*; Adams and Dale 1998a), calving sites for boreal ecotype caribou in Alberta are not associated with easily identifiable calving grounds, and data for Alberta and the Northwest Territories indicate that calving sites are dispersed throughout caribou range areas (Fish and Wildlife Division and Alberta Caribou Committee unpubl. data; Morton and Wynes 1997; J. Nagy unpubl. data).

All remaining boreal ecotype caribou populations are currently found in northern portions of the province, with the exception of the Little Smoky, which is the last boreal ecotype caribou population in west-central Alberta (Brown and Hobson 1998).

2. Mountain Ecotype Caribou **-** Habitat selection by migratory mountain ecotype caribou changes seasonally. In winter, mature and old lodgepole pine or mixed pine/spruce/fir forests in the foothills are most commonly used (Edmonds and Bloomfield 1984, Shepherd et al. 2007, Szkorupa 2002). In spring, mountain caribou move from winter range in the foothills to summer range in the mountains. During calving, female caribou are highly dispersed and are found in a variety of habitats within mountainous areas, including alpine, subalpine forest and treed and open peatland habitats (Edmonds and Smith 1991). During the breeding season in autumn, mountain caribou are typically found in alpine or subalpine meadows (Edmonds and Smith 1991).

The migratory patterns of some mountain caribou populations have changed dramatically in recent decades. The Banff (recently extirpated) and Jasper populations reside in the mountains year-round, moving from lower elevation subalpine areas to higher elevation subalpine and alpine habitats in the summer (Brown and Hobson 1998). These populations no longer migrate to forest foothills areas outside of the national parks for winter (Fish and Wildlife Division unpubl. report), possibly related to human-caused habitat alteration in the former winter ranges (Fish and Wildlife Division unpubl. report) and the high levels of caribou mortality typically associated with altered habitats. Similarly, since 1996, the traditional annual migration to foothills winter range has been abandoned by the majority of the A La Peche population with the exception of an estimated 30 animals (Smith 2004). As with the Jasper and Banff caribou populations, these changes for the A La Peche population may be related to high levels of anthropogenic habitat alteration and associated increases in caribou mortality in the former lower elevation winter range areas. In addition, there are some indications that the migratory behaviour of the Redrock-Prairie Creek mountain caribou population has changed over the last 20 years, with increasing emphasis on alpine areas as winter range and reduced use of lower elevation foothills (Fish and Wildlife Division unpubl. data). Considering the full suite of possible weather and climatic conditions that can occur along the eastern slopes, mountainous areas are considered to be suboptimal long-term winter range for woodland caribou in Alberta (K. Smith pers. comm.).

3. Separation from Predators - Relative safety from predation is a key feature of woodland caribou habitat. The susceptibility of woodland caribou to wolf predation has led to patterns of caribou habitat use that separate them from other ungulates, and thereby wolves, that occur in the same geographic areas (Bergerud and Page 1987, Seip 1992). For mountain ecotype caribou, this spatial separation occurs both when caribou occupy different winter habitat than other ungulates and when they migrate to calve at higher elevations than moose, deer and elk (Edmonds 1988, Edmonds and Smith 1991, Seip 1992; review by Saher and Schmiegelow 2005). Boreal caribou in Alberta do not migrate (Stuart-Smith et al. 1997); however, this ecotype separates itself from other ungulates by occupying habitat that has a lower density of other ungulate species year-round (Boreal Caribou Research Program 1998, 1999b, Dalerum et al. 2007, James 1999, James et al. 2004). Females of both ecotypes may further minimize predation by spacing themselves away from other caribou during the calving season (Bergerud 1988, Edmonds 1988, Fuller and Keith 1981, James et al. 2004, Stuart-Smith et al. 1997, Smith et al. 2000). In addition, the risk of predation is reduced under natural conditions since woodland caribou exist at very low population densities of approximately 0.03 to 0.12 caribou per square kilometre (Bergerud 1992, Seip 1991, Stuart-Smith et al. 1997).

The availability of extensive range areas is understood to be a key habitat characteristic, which allows caribou to minimize predation risk (Bergerud 1980, Bergerud et al. 1984). For example, survival probabilities are higher for individual boreal caribou that are able to space themselves away from upland habitat (McLoughlin et al. 2005).

4. Habitat Change and Fragmentation - Forest fire is a primary natural cause of habitat change in the boreal forest. In recent decades, the extent of area affected by forest fires on woodland caribou ranges has varied from very small in ranges such as the West Side Athabasca and all of the ranges in west-central Alberta, to fairly large in ranges such as Caribou Mountains, Cold Lake and Slave Lake (Table 3). The occurrence of mountain pine beetle (*Dendroctonus ponderosae*) is a second natural cause of habitat change, which is currently increasing in parts of the province in response to mild winter temperatures in recent years (E. Lee-Samis pers. comm.).

The primary anthropogenic disturbances to woodland caribou habitat in Alberta are due to oil and gas exploration and development and forest harvesting, and include the development of associated linear features (e.g., roads, pipelines, seismic lines). Peat harvesting and agricultural development have also affected caribou habitat in some cases, although peat

Table 3. Estimated extent of recent forest fires in woodland caribou ranges in Alberta.

Caribou Range	Percent of Range Area Covered by Burns (< 30 years old)[1]	Percent of Range Area Covered by Burns (< 50 years old)[2]
West Side Athabasca River	2.8	4.1
East Side Athabasca River	22.7	26.5
Yates	not available	29.6
Red Earth	25.5	28.8
Caribou Mountains	35.7	43.8
Bistcho	not available	24.3
Cold Lake	30.0	35.0
Chinchaga	2.6	10.9
Slave Lake	23.5	46.8
Nipisi	not available	6.0
Richardson	not available	19.7
Little Smoky	0.1	0.1
Redrock-Prairie Creek[3]	0.4	0.4
A La Peche[3]	0.0	0.0
Narraway	not available	0.0
Jasper[3]	not available	3.2

[1] Adapted from appendices to Boutin and Arienti (2008). Excludes unburned islands of forest within fire perimeters. Considers only Alberta portion of ranges that cross jurisdictional boundaries.

[2] Adapted from Environment Canada (2008) for West Side Athabasca River, East Side Athabasca River, Yates, Red Earth, Caribou Mtns., Bistcho, Cold Lake, Chinchaga, Slave Lake, Nipisi, and Richardson. (Note: Includes entire range area for ranges that cross jurisdictional boundaries). Adapted from Alberta Caribou Committee (2008) for Little Smoky, Redrock-Prairie Creek, A La Peche, Narraway, and Jasper. (Note: Includes only Alberta portion of ranges that cross jurisdictional boundaries).

[3] Estimates include portions of caribou ranges both on multiple-use provincial lands and within protected areas (i.e., Willmore Wilderness Park, Kakwa Wildland Provincial Park, Jasper National Park).

harvesting operations to date have not affected large areas of caribou habitat, and agricultural development has affected the margins of only some caribou ranges (D. Hervieux pers. comm.).

It is noted that there are very few sources of comparable summary information at a provincial scale describing the current extent of anthropogenic habitat change on individual caribou ranges within Alberta. Information compiled by Environment Canada, the University of Alberta and the Alberta Caribou Committee indicates that the total amount of anthropogenic habitat change (considering all disturbance types) is currently high on most provincial caribou ranges (Table 4), particularly in relation to seismic exploration lines (Table 5).

No summaries are available describing the current extent of forest harvesting on caribou ranges in Alberta; however, for the Chinchaga caribou range, Millson (2009) delineated areas of timber harvest blocks, associated reserve harvest blocks, and areas isolated by harvesting, and reported that 18% of the range is currently covered by this timber harvesting footprint. A similar review (completed as part of this status report update) using 2008 satellite imagery found that in west-central Alberta caribou ranges current timber harvesting footprint has covered

Table 4. Estimated percent of woodland caribou range area in proximity to all anthropogenic habitat disturbances on woodland caribou ranges in Alberta.

Caribou Range	Percent of Range in Proximity to Anthropogenic Disturbance
West Side Athabasca River[1]	42.7
East Side Athabasca River[1]	49.5
Yates[1]	32.2
Red Earth[1]	39.0
Caribou Mountains[1]	24.0
Bistcho[1]	40.1
Cold Lake[1]	45.7
Chinchaga[1]	58.5
Slave Lake[1]	67.7
Nipisi[1]	46.1
Richardson[1]	19.9
Little Smoky[2]	86.8
Redrock-Prairie Creek[2]	30.5 (46.0 excluding protected areas[3])
A La Peche[2]	17.0 (59.0 excluding protected areas[3])
Narraway[2]	55.6
Jasper[2]	9.2

[1] Adapted from Environment Canada (2008). Includes all visible linear and polygonal anthropogenic disturbances derived from Global Forest Watch Canada data set; buffered by 500 metres (which was the buffer distance on disturbance features selected by Global Forest Watch Canada). Includes entire range area for ranges that cross jurisdictional boundaries.

[2] Adapted from Alberta Caribou Committee (2008). Includes linear (>= 5 metres in width) and polygonal (Note: timber harvest cutblocks > 30 years old were not included) anthropogenic disturbances derived from Alberta Sustainable Resource Development and Alberta Energy GIS base-features databases and Alberta vegetation inventory, and National Parks base-features database; buffered by 250 metres. Includes only Alberta portion for ranges that cross jurisdictional boundaries.

[3] Protected areas include: Willmore Wilderness Park, Kakwa Wildland Provincial Park, Jasper National Park.

38% of the Little Smoky range, 35% of the Narraway range (within Alberta), 28% of the A La Peche winter range, and 23% of the Redrock/Prairie Creek winter range. Completing this satellite imagery-based review for northern Alberta caribou ranges is less feasible, because of difficulties in distinguishing timber harvest blocks from natural open areas such as peatland habitats, which are more abundant in northern Alberta.

Natural disturbances such as fire and forest insects can temporarily reduce the suitability of caribou habitat through various mechanisms, such as reduction and removal of caribou forage and altered snow conditions (Cichowski 2007, Dunford et al. 2006). Habitat change as a result of human activities can result in both physical loss of habitat and reduced use of adjacent areas by woodland caribou (e.g., Dyer et al. 2001, Smith et al. 2000). Both natural and human-caused habitat change can also cause increased caribou mortality as a result of wolf population increases associated with habitat-mediated increases in other ungulate prey species (Bergerud and Elliot 1986, Lessard 2005, Seip 1992, Wittmer et al. 2005a). In addition, human-caused habitat changes can result in increased predator travel efficiency and hunting success (James 1999, James and Stuart-Smith 2000).

Table 5. Estimated amount of anthropogenic habitat change related to linear feature development on woodland caribou ranges in Alberta[1].

Caribou Range	Linear Feature[2] Density (km/km^2)	Percent of Range Area Covered by Roads / Percent Area including 200m Buffer on Roads	Percent of Range Area Covered by Pipelines / Percent Area including 200m Buffer on Pipelines	Percent of Range Area Covered by Seismic Lines / Percent Area including 200m Buffer on Lines
West Side Athabasca River[3]	1.2	0.1 / 1.1	0.4 / 2.9	0.5 / 18.0
East Side Athabasca River[3]	1.8	0.1 / 1.1	0.7 / 5.1	0.7 / 24.0
Yates[3]	not available	not available	not available	not available
Red Earth[3]	2.1	0.1 / 1.0	0.2 / 1.4	1.0 / 30.7
Caribou Mountains [3]	0.9	0.01 / 0.1	0.01 / 0.04	0.4 / 15.4
Bistcho[3]	not available	not available	not available	not available
Cold Lake (Alberta portion) [3]	1.2	0.1 / 0.4	0.7 / 5.4	0.4 / 14.6
Chinchaga[3]	3.4	0.2 / 1.4	0.4 / 2.7	1.6 / 46.0
Slave Lake[3]	2.7	0.5 / 4.7	1.2 / 8.4	1.0 / 34.7
Nipisi[3]	not available	not available	not available	not available
Richardson[3]	not available	not available	not available	not available
Little Smoky[3]	3.7	0.5 / 4.6	0.5 / 3.7	1.7 / 49.2
Redrock-Prairie Creek[3,4]	0.8	0.3 / 3.1	0.2 / 1.4	0.3 / 11.0
A La Peche[3,4]	0.6	0.2 / 1.8	0.1 / 0.5	0.3 / 8.6
Narraway[5]	1.9	0.6 / not available	0.4 / not available	0.5 / not available
Jasper[4,5]	0.3	0.2 / not available	0.0	0.0

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[1] Considers only Alberta portion of ranges that cross jurisdictional boundaries.

[2] Includes roads, pipelines and conventional seismic lines, and in Jasper also includes major trails.

[3] Adapted from appendices to Boutin and Arienti 2008.

[4] Includes portions of caribou ranges both on multiple-use provincial lands and within protected areas (i.e., Willmore Wilderness Park, Kakwa Wildland Provincial Park, Jasper National Park).

[5] Adapted from unpublished portions of Alberta Caribou Committee (2008).

Research conducted in Alberta (Boutin and Arienti 2008, Dunford 2003, Smith 2004, Sorenson et al. 2008) and across Canada (e.g., Environment Canada 2008; also see below: "Limiting Factors") indicates that woodland caribou survival rates and the finite rate of population growth (lambda; λ) are significantly lower in caribou ranges with more anthropogenic and natural disturbance and/or in close proximity to anthropogenic and natural disturbance.

CONSERVATION BIOLOGY

1. Appearance and Winter Adaptations - Caribou are medium-sized members of the deer family. They are recognized by their brown pelage, cream-coloured neck and mane, and large, intricate, forward-curving antlers. Males and most females have antlers, although the females' antlers are smaller. Caribou are well adapted to harsh winter conditions (Telfer and Kelsall 1984, White et al. 1981). Their large, crescent-shaped hooves and relatively long legs are useful for digging through snow to reach forage, and provide effective weight distribution for locomotion over snow or peatland (Fancy and White 1985, Klein 1992, Klein et al. 1987). Other adaptations to winter conditions include short extremities (ears and tail), and hollow hair that provides excellent insulation and covers the entire body including the muzzle. To further reduce heat loss, caribou have a slower metabolism and a reduced rate of movement in most late winters when deep, crusted snow makes travel energetically expensive (Banfield 1974, Klein 1992, Schneider et al. 1999). Despite these adaptations, fat reserves accumulated in summer are depleted during winter (Adamczewski et al. 1987, Dauphine Jr. 1976, Gerhart et al. 1996a). Pregnant females divert nutrients to their growing fetuses throughout the winter with costs to the mother increasing exponentially during gestation (Robbins 1983). Long, harsh winters with deep, crusted snow can thus compromise body condition and survival of adults, juveniles, and unborn fetuses (Adams et al. 1995).

2. Reproduction - The rutting season occurs in early to mid-October (Edmonds and Bloomfield 1984). Bulls tend to be polygamous, collecting and defending harems of 12 to 15 cows (Banfield 1974). Males forage little during the breeding season (Banfield 1974) and may lose up to 25% of their body weight (Bergerud 1983). By November, mountain ecotype animals begin to move to foothills wintering areas, whereas boreal ecotype caribou disperse into smaller groups throughout their annual home range.

Caribou have a gestation period of approximately 7.5 to 8 months (Banfield 1974). In northern Alberta, most calves are born in the first two weeks of May (Morton and Wynes 1997). This is approximately one month earlier than the mountain ecotype in west-central Alberta where most calves are born during the first two weeks of June (Edmonds and Bloomfield 1984, Edmonds 1988, Edmonds and Smith 1991), probably in response to the timing of snow retreat in alpine calving areas. Caribou calving dates in northern Alberta are also earlier than the boreal ecotype Little Smoky population in west-central Alberta (last 2 weeks of May; Smith and Pittaway 2010), and earlier than woodland caribou calving in several other areas of North America (Brown and Theberge 1990, Hatler 1986).

In comparison to other forest-dwelling ungulate species, woodland caribou exhibit low reproductive potential. Adult cows typically are three years of age before they begin producing young and only produce a single calf annually (Adams and Dale 1998b). The average age of female caribou in northeastern Alberta was determined to be 6.9 years (Fuller and Keith 1981). Depending on their nutritional status, females that are 1.5 years old may occasionally breed and produce young as two-year-olds (Dauphine Jr. 1976, Adams and Dale 1998b, Rettie and Messier 1998). Work in Alberta demonstrated pregnancy rates to be very high in females over 2.5 years of age (Boreal Caribou Research Program 1998, Edmonds and Smith 1991, McLoughlin et al. 2003, Stuart-Smith et al. 1997). Similarly, visual surveys of radio-collared females with newborn calves revealed calf production to be high (>80% of all females; Fish and Wildlife unpubl. data; Morton and Wynes 1997). These high and relatively invariant rates of pregnancy and calf production are comparable to barren-ground and woodland caribou elsewhere in Canada (Bergerud 1980, Bergerud 1983).

3. Survival **-** Juvenile survival in the first year of life for caribou can be highly variable. A common temporal pattern is for caribou calf mortality to be highest in the first 30 days after birth (e.g., Mahoney et al. 1990, Stuart-Smith et al. 1997). Survival rates approach adult levels after the first year of life (Davis et al. 1988, Whitten et al. 1992). Bergerud (1974) suggested caribou populations composed of less than 10% calves in late winter are likely declining, although the exact nature of this relationship depends on levels of adult mortality within a given year. Variability in juvenile survival plays an important role in determining population dynamics of ungulates such as woodland caribou (Gaillard et al. 1998).

Although survival of adult caribou can be low, it is typically higher than juveniles, and often shows less year-to-year variation (Bergerud 1980, Hearn et al. 1990, Seip 1992, Rettie and Messier 1998). Unless balanced by adequate survival and recruitment of calves to the population, even modest annual levels of adult caribou mortality can lead to population declines; small declines in adult female survival can lead to large declines in population size (Fancy et al. 1994, Gaillard et al. 1998, 2000).

4. Mortality **-** Predation, primarily by wolves, is recognized as the most important natural mortality factor for caribou populations (Bergerud 1988, Boertje et al. 1996, Boertje and Gardner 1998, Edmonds 1988, Fuller and Keith 1981, McLoughlin et al. 2003, Seip 1992, Stuart-Smith et al. 1997; see Gustine et al. 2006). Research completed in Alberta supports the contention that predation is a very significant source of mortality; it is the cause of more than one-half and possibly three-quarters of adult female mortality (Figure 8). Annually since the late winter of 2005/06, the Alberta government

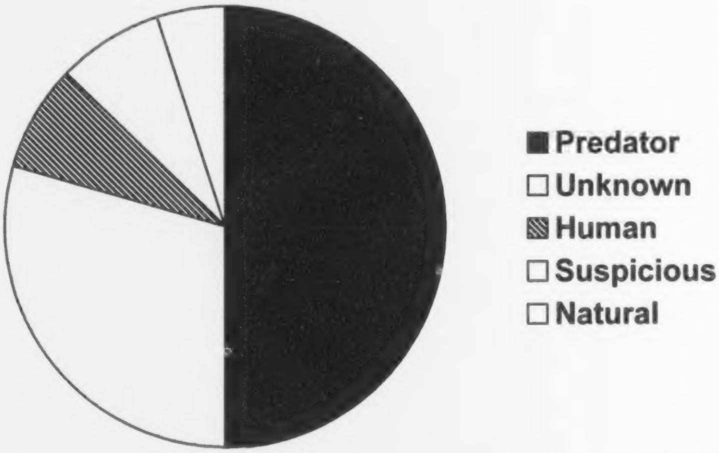

Figure 8. Causes of mortality for collared adult female caribou (n = 102) in northern Alberta, 1992 to June 2000. "Suspicious" means humans were suspected in causing the death of the caribou; criteria included sudden loss of signal with no indication of radio collar transmitter or battery malfunction (adapted from Dzus 2001).

has implemented a wolf population reduction program during the winter, within and adjacent to the Little Smoky caribou range (including in a portion of the A La Peche caribou range), in an effort to protect that caribou population from imminent extirpation. Coincident with the implementation of wolf management, the Little Smoky caribou population quickly achieved a state of approximate population stability, in contrast to a consistent pattern of long-term population declines prior to wolf management (see below; "Population Size and Trends"). This wolf population reduction program may also be contributing to maintaining population stability of the adjacent A La Peche caribou population. It should be noted that the Little Smoky population, in particular, still has a relatively small population size and therefore remains vulnerable.

Bears (*Ursus* spp.), coyotes (*Canis latrans*), wolverines (*Gulo gulo*), cougar (*Felis concolor*) and lynxes (*Lynx canadensis*) may also be predators on caribou in some cases (Ballard 1994, Mahoney et al. 1990, Stephenson et al. 1991, Wilson 2008). In addition to predation, mortality factors for calves may include starvation, inclement weather, and reduced size at birth after hard winters (Bergerud 1983).

5. Diet - Terrestrial and arboreal lichens are the primary winter food for caribou in Alberta (Edmonds and Bloomfield 1984, Thomas et al. 1996). Studies in Alberta and British Columbia indicate that, although terrestrial lichens are the preferred winter forage, arboreal lichens are also used, especially in habitats with high abundance of arboreal lichens, or when deep or hard snow make digging for terrestrial lichens difficult (Cichowski 1993, 2009, Johnson 2000, Thomas et al. 1996). The summer diet of caribou is much more varied, including terrestrial lichens, shrubs, grasses, sedges, horsetails, and forbs (Boertje 1984, Cichowski 1993, Thomas and Armbruster 1996; D. Thomas pers. comm.).

Terrestrial lichen abundance depends on site conditions and the amount of time since disturbance; they are often most abundant in mature to old forests, or on sites with low productivity where conditions are unfavourable for their competitors. Two successional pathways are possible: one where terrestrial lichens increase with time since disturbance and are abundant in climax forests (typically on dry, nutrient-poor sites); and one where terrestrial lichen abundance increases with time since disturbance, but eventually declines because of competition from vascular plants or mosses (typically on mesic/submesic sites; Cichowski 2008). Dunford et al. (2006) found that terrestrial lichen biomass recovered to pre-disturbance levels 40 years after fire disturbance in northern Alberta peatlands.

POPULATION SIZE AND TRENDS

1. Alberta - In Alberta and most other jurisdictions, estimating woodland caribou population size through census (i.e., counting of all individual animals) or by observing a sample of the total population through aerial surveys is generally not feasible because of the cryptic coloration and relatively small body size of caribou, combined with the dense conifer forests present within most caribou ranges (which often make it impossible to observe the ground). In addition, the low population density and clumped distribution of woodland caribou across very large range areas affect the feasibility of census surveys. Alternatively, annual rates of population change (population growth or decline) are being estimated from data for adult female survival and female calf recruitment; values for the finite annual rate of population increase (lambda; λ) are now being calculated for the adult female component of most provincial caribou populations. Monitoring data are sufficient for calculating lambda values for 13 caribou populations[4] in the province; these values have been calculated for some populations since 1993/94.

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[4] Sufficient data are currently unavailable for the Slave Lake, Nipisi and Richardson populations.

Annual adult caribou survival rates are calculated based on survival of radio-collared female caribou using Pollock et al.'s (1989) staggered-entry modification of the Kaplan-Meier (1958) survivorship model. Annual adult female caribou survival for monitored populations in the province has ranged from 61.4% to 100% (Table 6).

Female caribou calf recruitment to nine months of age is being estimated from the number of female calves[5] observed relative to the number of adult females during late winter caribou population composition surveys. It is noted that this technique probably overestimates the number of calves recruiting to the breeding population, since further calf and

Table 6. Geometric mean of annual adult female survival (%) for caribou populations in Alberta, May 1993 – April 2009. Estimates were derived from a radio-collared sample of adult female caribou (target of 25 to 30 radio-collared animals per population at the start of each year) between May 1 and April 30 (June 1 and May 31 for Jasper) of each year. Survival was estimated using Pollock et al.'s (1989) staggered-entry modification of Kaplan and Meier's (1958) survivorship model (Kaplan-Meier PL Estimator of Survival Rate, Version 2.1, Exeter Software, 47 Route 25A, Setauket, New York, New York, USA, coded by C. J. Krebs - University of British Columbia).

Population	Geometric Mean	Range	Number of Years
West Side Athabasca River	86.2	72.2–94.1	16
East Side Athabasca River	84.9	75.0–94.4	16
Yates	94.1	93.3–95.0	2
Red Earth	84.6	70.8–100	14
Caribou Mountains	84.9	69.6–100	14
Bistcho	83.1	75.0–93.0	4
Cold Lake (combined AB&SK)[1]	85.9	73.9–95.5	10
Cold Lake (AB)	81.6	61.9–95.2	10
Cold Lake (SK)	89.0	75.3–100	10
Chinchaga	84.6	75.0–100	7
Slave Lake & Nipisi (combined)[2]	88.3	71.4–100	6
Richardson			0
Little Smoky	85.9	73.1–94.7	10
Redrock-Prairie Creek	85.9	61.4–100	11
A La Peche	91.5	78.0–100	11
Narraway	82.8	77.4–88.5	2
Jasper	88.0	69.4–100	8

[1] Data have been collected separately for segments of this population occurring on the Saskatchewan (SK) and Alberta (AB) portions of the Cold Lake range, in an attempt to compare caribou vital rates for parts of the range that initially had higher (AB) and lower (SK) levels of industrial development.

[2] Combined data have been collected for these populations, owing to the initial (incorrect) belief that only a single population was present on the two range areas.

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[5] Based on one-half of the total number of calves observed (assuming equal sex ratio of calves at time of survey).

juvenile mortality will occur prior to animals reaching breeding age (i.e., this technique may underestimate population declines and overestimate population increases; implications of this, and of delayed age of first reproduction by female caribou, for woodland caribou population growth thresholds are currently being investigated by DeCesare et al. [2010]). The proportion of female calves per adult female has ranged from 0.01 to 0.26 female calves per adult female (Table 7).

In recent years, high calf mortality coupled with moderate to high adult female mortality has resulted in a pattern of lambda (λ) values of less than 1.0 (i.e., populations in decline) for the adult female component of most monitored woodland caribou populations in Alberta (Table 8; Figures 9a to 21a). It should be noted that the lambda (λ) values listed in this status report are provided without estimates of associated variance or measurement error. Work is currently ongoing within the Alberta Caribou Committee's Research and Monitoring Subcommittee to represent confidence intervals around annual lambda (λ) estimates, based on procedures as described by Fieberg and Ellner (2001), Kaye and Pyke (2003) and Morris and Doak (2002). Similar work is ongoing for the Jasper caribou population (M. Hebblewhite pers. comm.).

Figures 9(b) to 21(b) provide an estimate of the percent change in the size of the adult female

Table 7. Geometric mean of the annual proportion of female calves (assuming equal sex ratios at time of survey) per adult female for caribou populations in Alberta, May 1993 – April 2009. Values were derived from annual estimates of the calves per adult female based on the proportion of adult females seen with calves during late February/early March population composition surveys (i.e., calves at 9 to 10 months of age); used as estimates of calf recruitment to the population. Total number of caribou classified during annual population composition surveys is provided in Appendix 2.

Population	Geometric Mean	Range	Number of years
West Side Athabasca River	0.11	0.08–0.18	16
East Side Athabasca River	0.07	0.04–0.15	15
Yates	0.08	0.08–0.08	2
Red Earth	0.08	0.04–0.23	15
Caribou Mountains	0.07	0.03–0.12	15
Bistcho	0.07	0.06–0.10	4
Cold Lake (combined AB&SK)[1]	0.09	0.04–0.15	9
Cold Lake (AB)	0.07	0.02–0.16	10
Cold (SK)	0.09	0.04–0.15	9
Chinchaga	0.08	0.04–0.16	8
Slave Lake & Nipisi (combined)[2]	0.12	0.02–0.26	8
Richardson	0.15	0.15–0.15	1
Little Smoky	0.07	0.01–0.11	10
Redrock-Prairie Creek	0.09	0.03–0.13	11
A La Peche	0.09	0.03–0.17	11
Narraway	0.06	0.01–0.10	2
Jasper	0.13	0.07–0.21	6

[1] Data have been collected separately for segments of this population occurring on the Saskatchewan (SK) and Alberta (AB) portions of the Cold Lake range, in an attempt to compare caribou vital rates for parts of the range that initially had higher (AB) and lower (SK) levels of industrial development.

[2] Combined data have been collected for these populations, owing to the initial (incorrect) belief that only a single population was present on the two range areas.

Table 8. Annual population growth rate (lambda; λ) for the adult female component of caribou populations in Alberta, May 1993 – April 2009. A lambda value of 1.0 indicates a stable population. Values greater than 1.0 indicate the magnitude of population growth and values less than 1.0 indicate the magnitude of population decline (i.e., a value of 1.10 indicates a 10% annual increase in population size and a value of 0.90 indicates a 10% annual decrease). Values were calculated using annual estimates of calf recruitment[1] and adult survival[2] for each population.

Population	**93-94**	**94-95**	**95-96**	**96-97**	**97-98**	**98-99**	**99-00**	**00-01**	**01-02**	**02-03**	**03-04**	**04-05**	**05-06**	**06-07**	**07-08**	**08-09**
West Side Athabasca River	1.07	0.98	0.92	1.01	1.10	1.01	0.88	0.97	1.01	0.83	0.96	0.97	0.97	0.97	0.90	0.78
East Side Athabasca River	0.93	0.99	0.93	1.01		1.04	0.98	0.85	0.88	1.00	0.94	0.80	0.93	0.88	0.81	0.84
Yates															1.03	1.01
Red Earth			0.91	0.80	1.23	0.84	1.06	0.82	1.04	0.96	0.91	0.87	0.77	0.95	0.86	0.84
Caribou Mountains			1.08	1.12	0.85	1.02	0.80	0.87	0.96	0.78	0.93	0.84	0.75	0.93	0.93	0.91
Bistcho													0.95	0.82	0.99	0.80
Cold Lake (combined AB&SK)[3]						1.03	0.95	0.94	0.96		0.95	0.96	0.81	0.97	0.77	0.81
Cold Lake (AB)						1.04	1.02	0.94	0.95		0.91	0.94	0.66	0.77	0.75	0.71
Cold Lake (SK)						1.03	0.88	0.94	0.99		1.01	1.00	0.98	1.06	0.80	0.91
Chinchaga										0.83	0.93	1.05	0.80	0.97	0.82	0.89
Slave Lake[4]																
Nipisi[4]																
Richardson																
Little Smoky[5]							0.89	0.93	0.92	0.79	0.90	1.03	0.77	0.96	0.97	1.05
Redrock-Prairie Creek						1.12	1.05	0.76	1.11	0.90	1.00	0.70	1.09	0.77	0.90	0.94
A La Peche						1.10	1.02	1.05	1.02	1.01	1.07	0.99	0.94	0.99	0.86	1.06
Narraway															0.90	0.85
Jasper											1.06	0.95	0.97	1.01	0.97	0.83

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[1] Derived from annual estimates of the number of female calves per adult female, based on the proportion of adult females seen with calves during late February/early March population composition surveys (i.e., calves at 9 to 10 months of age). Total number of caribou classified during annual composition surveys is provided in Appendix 2. Actual population declines may be greater and population increases may be less than calculated lambda values, since population composition surveys do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

[2] Estimates derived from a radio-collared sample of adult female caribou (target of 25 to 30 radio-collared animals per population at the start of each year) between May 1 and April 30 (June 1 and May 31 for Jasper) of each year. Survival was estimated using Pollock et al.'s (1989) staggered-entry modification of Kaplan and Meier's (1958) survivorship model (Kaplan-Meier PL Estimator of Survival Rate, Version 2.1, Exeter Software, 47 Route 25A, Setauket, New York, New York, USA, coded by C. J. Krebs - University of British Columbia).

[3] Monitoring data have been collected separately for segments of this population occurring on the Saskatchewan (SK) and Alberta (AB) portions of the Cold Lake range, in an attempt to compare caribou vital rates for parts of the range that initially had higher (AB) and lower (SK) levels of industrial development. Lambda value for Cold Lake (SK) in 2004-05 was set at 1.0, based on 100% female survival; no calf survey data were collected in that year.

[4] Population growth rates not calculated because of the potential effects of low annual samples of radio-collared adult females (often 10 or fewer females collared per range) on adult survival estimates.

[5] Annual wolf population control program began in late winter of 2005/06 (after most within-year adult and calf mortality had already occurred); potential benefits of wolf control for both adult and calf caribou survival were available to the caribou population in 2006/07, 2007/08, and 2008/09.

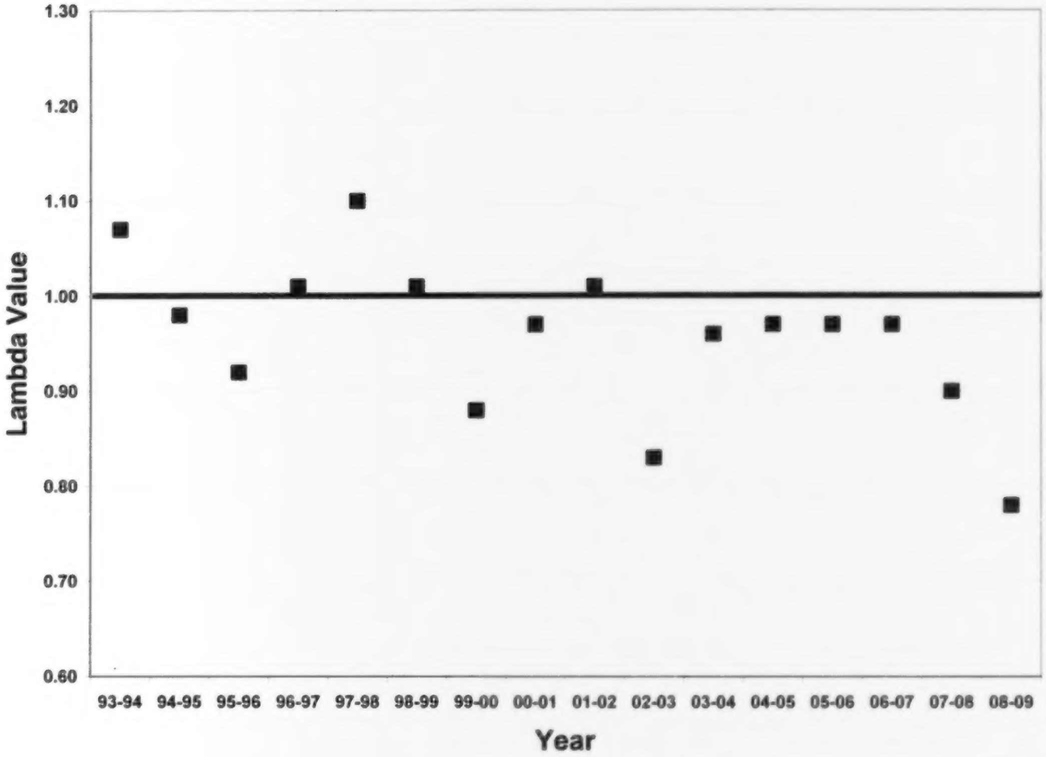

Figure 9(a). Annual population growth rate (lambda; λ) for the adult female component of the West Side Athabasca River caribou population. Lambda values of 1.0 indicate population stability. Values greater than 1.0 indicate the magnitude of population growth and values less than 1.0 indicate the magnitude of population decline. Values were calculated using annual estimates of female calf recruitment[1] and adult female survival[2].

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[1] Derived from annual estimates of the number of female calves per adult female, based on the proportion of adult females seen with calves during late February/early March population composition surveys (i.e., calves at 9 to 10 months of age). Total number of caribou classified during annual population composition surveys is provided in Appendix 2. Actual population declines may be greater and population increases may be less than calculated lambda values, since population composition surveys do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

[2] Estimates derived from a radio-collared sample of adult female caribou (target of 25 to 30 radio-collared animals per population at the start of each year) between May 1 and April 30 of each year. Survival was estimated using Pollock et al.'s (1989) staggered-entry modification of Kaplan and Meier's (1958) survivorship model (Kaplan-Meier PL Estimator of Survival Rate, Version 2.1, Exeter Software, 47 Route 25A, Setauket, New York, New York, USA, coded by C. J. Krebs - University of British Columbia).

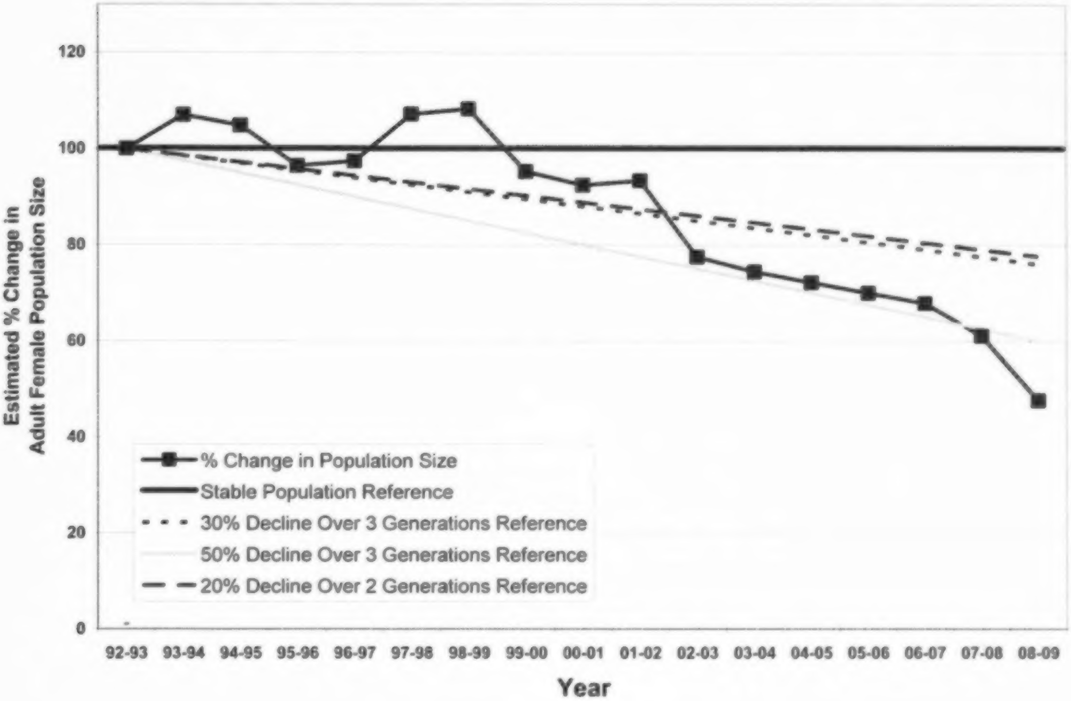

Figure 9(b). Estimated percent change in adult female population size for the West Side Athabasca River caribou population. Values were calculated by applying annual population growth rate estimates (lambda; λ) to the preceding year's adult female population estimate. The population was set at 100% at the beginning of the monitoring period. The 30% and 50% decline reference lines illustrate the slope of theoretical population declines of 30% and 50% over 20 years (i.e., 3 caribou generations, based on an average female age of 6.9 years; Fuller and Keith 1981), assuming a constant rate of decline. The 20% decline reference line gives the slope of a theoretical population decline of 20% over 14 years (i.e., 2 caribou generations). Actual population declines may be greater and population increases may be less than shown, since annual lambda estimates are based on population composition surveys which do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

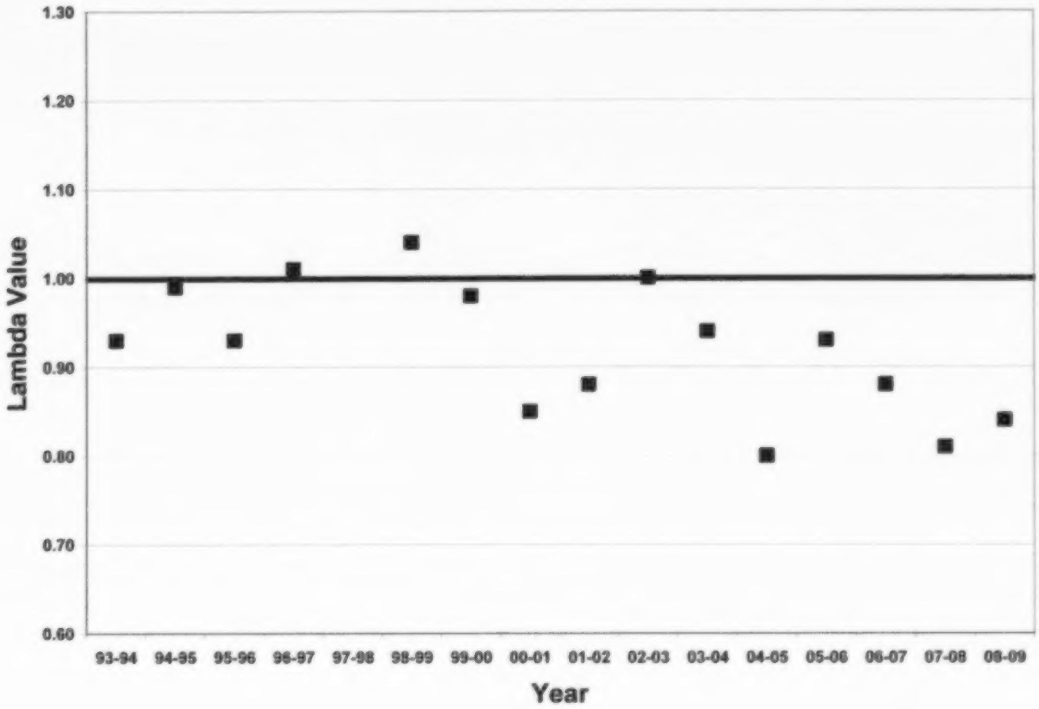

Figure 10(a). Annual population growth rate (lambda; λ) for the adult female component of the East Side Athabasca River caribou population. Lambda values of 1.0 indicate population stability. Values greater than 1.0 indicate the magnitude of population growth and values less than 1.0 indicate the magnitude of population decline. Values were calculated using annual estimates of calf recruitment[1] and adult survival[2].

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[1] Derived from annual estimates of the number of female calves per adult female, based on the proportion of adult females seen with calves during late February/early March population composition surveys (i.e., calves at 9 to 10 months of age). Total number of caribou classified during annual population composition surveys is provided in Appendix 2. Actual population declines may be greater and population increases may be less than calculated lambda values, since population composition surveys do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

[2] Estimates derived from a radio-collared sample of adult female caribou (target of 25 to 30 radio-collared animals per population at the start of each year) between May 1 and April 30 of each year. Survival was estimated using Pollock et al.'s (1989) staggered-entry modification of Kaplan and Meier's (1958) survivorship model (Kaplan-Meier PL Estimator of Survival Rate, Version 2.1, Exeter Software, 47 Route 25A, Setauket, New York, New York, USA, coded by C. J. Krebs - University of British Columbia).

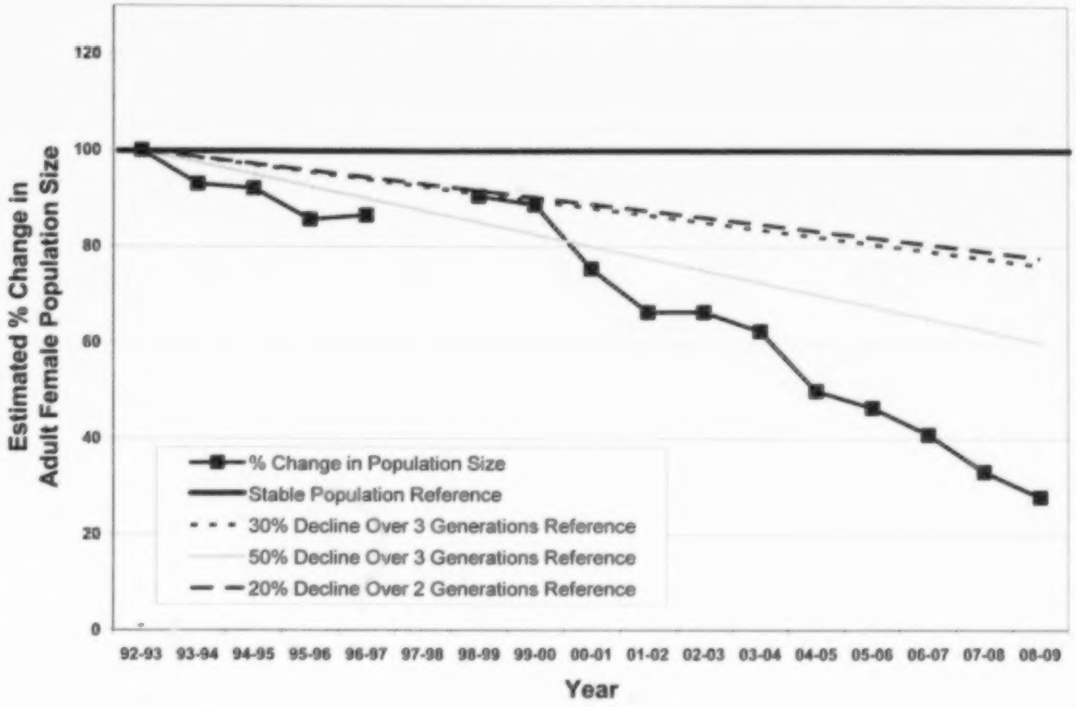

Figure 10(b). Estimated percent change in adult female population size for the East Side Athabasca River caribou population. Values were calculated by applying annual population growth rate estimates (lambda; λ) to the preceding year's adult female population estimate. The population was set at 100% at the beginning of the monitoring period. The 30% and 50% decline reference lines illustrate the slope of theoretical population declines of 30% and 50% over 20 years (i.e., 3 caribou generations, based on an average female age of 6.9 years; Fuller and Keith 1981), assuming a constant rate of decline. The 20% decline reference line gives the slope of a theoretical population decline of 20% over 14 years (i.e., 2 caribou generations). Actual population declines may be greater and population increases may be less than shown, since annual lambda estimates are based on population composition surveys which do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population. Note: A population growth rate estimate was not available for 1997-98; no percent change in population size was assigned for 1997-98, relative to 1996-97.

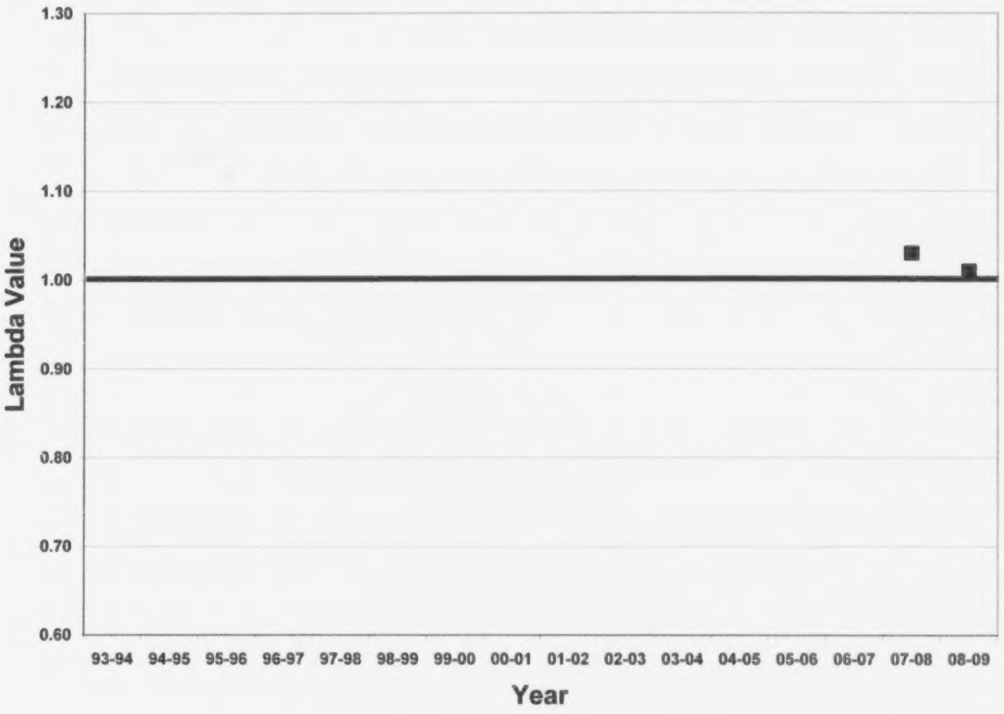

Figure 11(a). Annual population growth rate (lambda; λ) for the adult female component of the Yates caribou population. Lambda values of 1.0 indicate population stability. Values greater than 1.0 indicate the magnitude of population growth and values less than 1.0 indicate the magnitude of population decline. Values were calculated using annual estimates of calf recruitment[1] and adult survival[2].

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[1] Derived from annual estimates of the number of female calves per adult female, based on the proportion of adult females seen with calves during late February/early March population composition surveys (i.e., calves at 9 to 10 months of age). Total number of caribou classified during annual population composition surveys is provided in Appendix 2. Actual population declines may be greater and population increases may be less than calculated lambda values, since population composition surveys do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

[2] Estimates derived from a radio-collared sample of adult female caribou (target of 25 to 30 radio-collared animals per population at the start of each year) between May 1 and April 30 of each year. Survival was estimated using Pollock et al.'s (1989) staggered-entry modification of Kaplan and Meier's (1958) survivorship model (Kaplan-Meier PL Estimator of Survival Rate, Version 2.1, Exeter Software, 47 Route 25A, Setauket, New York, New York, USA, coded by C. J. Krebs - University of British Columbia).

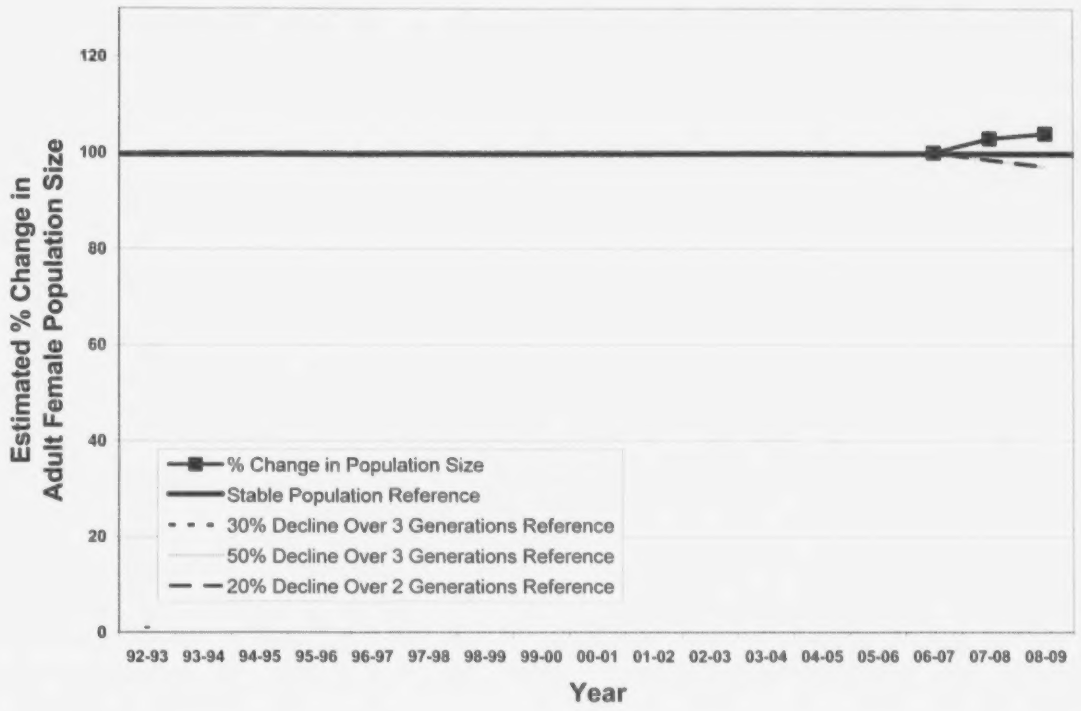

Figure 11(b). Estimated percent change in adult female population size for the Yates caribou population. Values were calculated by applying annual population growth rate estimates (lambda; λ) to the preceding year's adult female population estimate. The population was set at 100% at the beginning of the monitoring period. The 30% and 50% decline reference lines illustrate the slope of theoretical population declines of 30% and 50% over 20 years (i.e., 3 caribou generations, based on an average female age of 6.9 years; Fuller and Keith 1981), assuming a constant rate of decline. The 20% decline reference line gives the slope of a theoretical population decline of 20% over 14 years (i.e., 2 caribou generations). Actual population declines may be greater and population increases may be less than shown, since annual lambda estimates are based on population composition surveys which do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

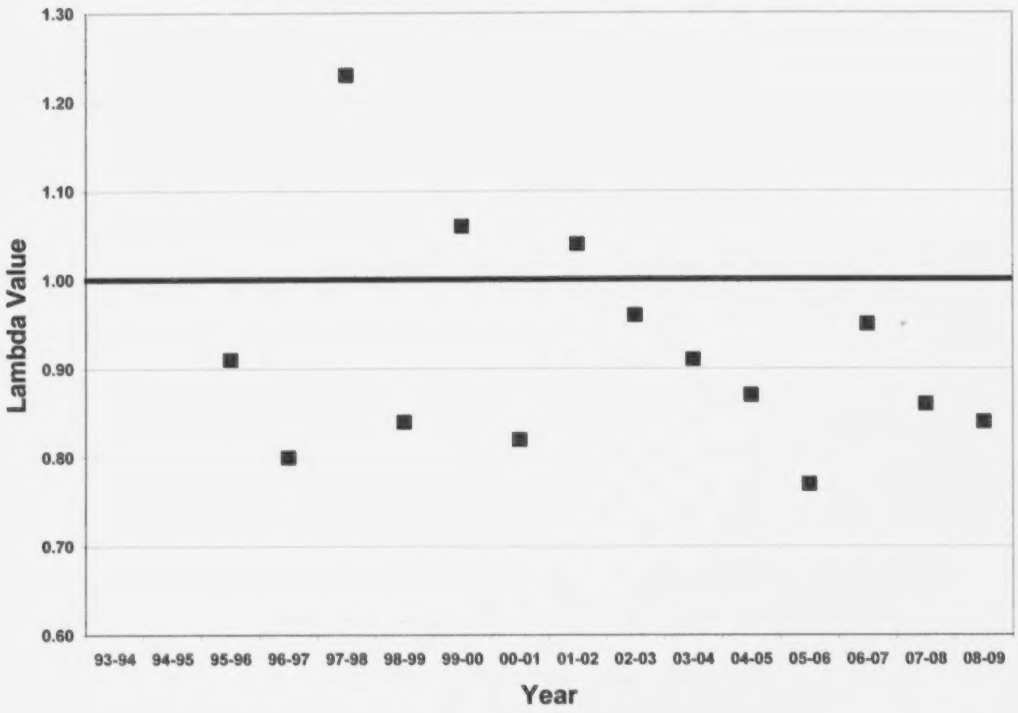

Figure 12(a). Annual population growth rate (lambda; λ) for the adult female component of the Red Earth caribou population. Lambda values of 1.0 indicate population stability. Values greater than 1.0 indicate the magnitude of population growth and values less than 1.0 indicate the magnitude of population decline. Values were calculated using annual estimates of calf recruitment[1] and adult survival[2].

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[1] Derived from annual estimates of the number of female calves per adult female, based on the proportion of adult females seen with calves during late February/early March population composition surveys (i.e., calves at 9 to 10 months of age). Total number of caribou classified during annual population composition surveys is provided in Appendix 2. Actual population declines may be greater and population increases may be less than calculated lambda values, since population composition surveys do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

[2] Estimates derived from a radio-collared sample of adult female caribou (target of 25 to 30 radio-collared animals per population at the start of each year) between May 1 and April 30 of each year. Survival was estimated using Pollock et al.'s (1989) staggered-entry modification of Kaplan and Meier's (1958) survivorship model (Kaplan-Meier PL Estimator of Survival Rate, Version 2.1, Exeter Software, 47 Route 25A, Setauket, New York, New York, USA, coded by C. J. Krebs - University of British Columbia).

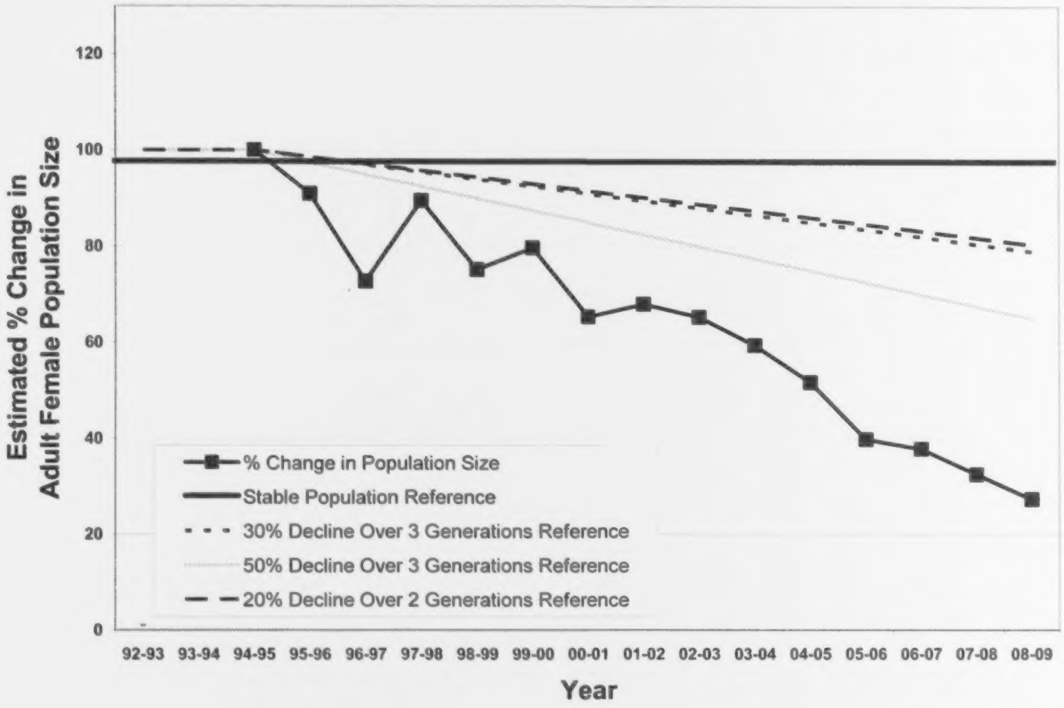

Figure 12(b). Estimated percent change in adult female population size for the Red Earth caribou population. Values were calculated by applying annual population growth rate estimates (lambda; λ) to the preceding year's adult female population estimate. The population was set at 100% at the beginning of the monitoring period. The 30% and 50% decline reference lines illustrate the slope of theoretical population declines of 30% and 50% over 20 years (i.e., 3 caribou generations, based on an average female age of 6.9 years; Fuller and Keith 1981), assuming a constant rate of decline. The 20% decline reference line gives the slope of a theoretical population decline of 20% over 14 years (i.e., 2 caribou generations). Actual population declines may be greater and population increases may be less than shown, since annual lambda estimates are based on population composition surveys which do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

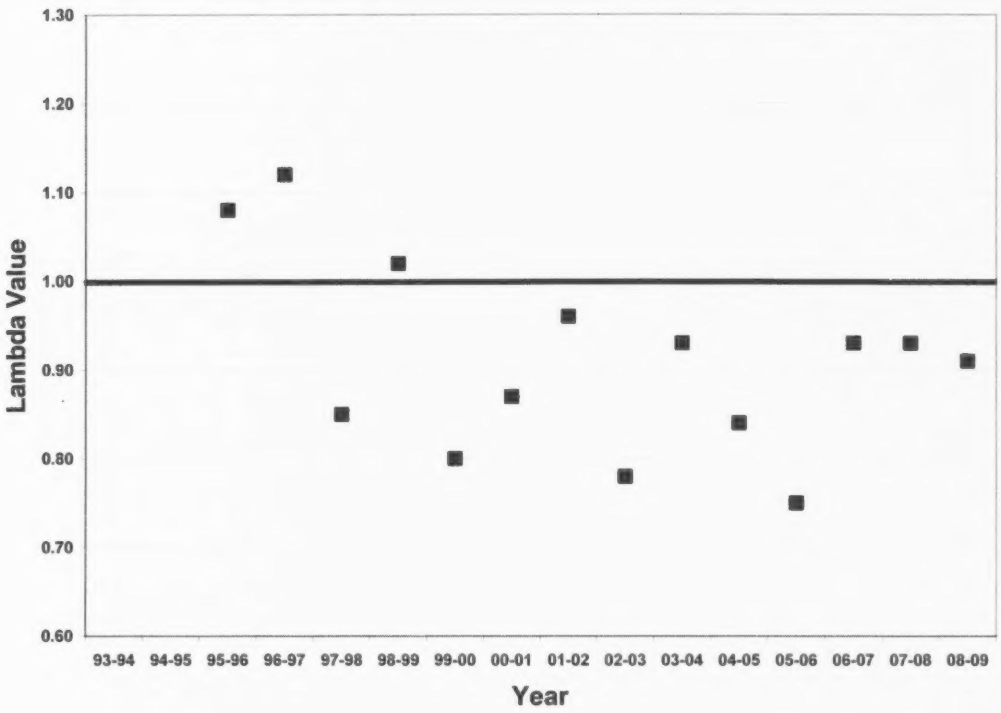

Figure 13(a). Annual population growth rate (lambda; λ) for the adult female component of the Caribou Mountains caribou population. Lambda values of 1.0 indicate population stability. Values greater than 1.0 indicate the magnitude of population growth and values less than 1.0 indicate the magnitude of population decline. Values were calculated using annual estimates of calf recruitment[1] and adult survival[2].

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[1] Derived from annual estimates of the number of female calves per adult female, based on the proportion of adult females seen with calves during late February/early March population composition surveys (i.e., calves at 9 to 10 months of age). Total number of caribou classified during annual population composition surveys is provided in Appendix 2. Actual population declines may be greater and population increases may be less than calculated lambda values, since population composition surveys do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

[2] Estimates derived from a radio-collared sample of adult female caribou (target of 25 to 30 radio-collared animals per population at the start of each year) between May 1 and April 30 of each year. Survival was estimated using Pollock et al.'s (1989) staggered-entry modification of Kaplan and Meier's (1958) survivorship model (Kaplan-Meier PL Estimator of Survival Rate, Version 2.1, Exeter Software, 47 Route 25A, Setauket, New York, New York, USA, coded by C. J. Krebs - University of British Columbia).

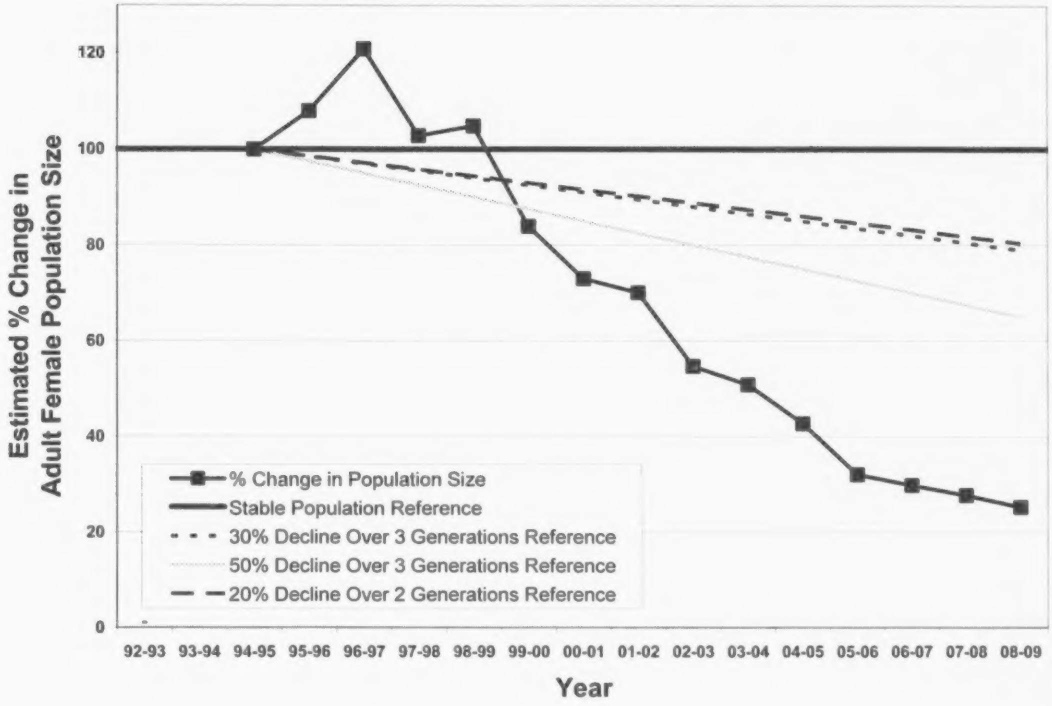

Figure 13(b). Estimated percent change in adult female population size for the Caribou Mountains caribou population. Values were calculated by applying annual population growth rate estimates (lambda; λ) to the preceding year's adult female population estimate. The population was set at 100% at the beginning of the monitoring period. The 30% and 50% decline reference lines illustrate the slope of theoretical population declines of 30% and 50% over 20 years (i.e., 3 caribou generations, based on an average female age of 6.9 years; Fuller and Keith 1981), assuming a constant rate of decline. The 20% decline reference line gives the slope of a theoretical population decline of 20% over 14 years (i.e., 2 caribou generations). Actual population declines may be greater and population increases may be less than shown, since annual lambda estimates are based on population composition surveys which do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

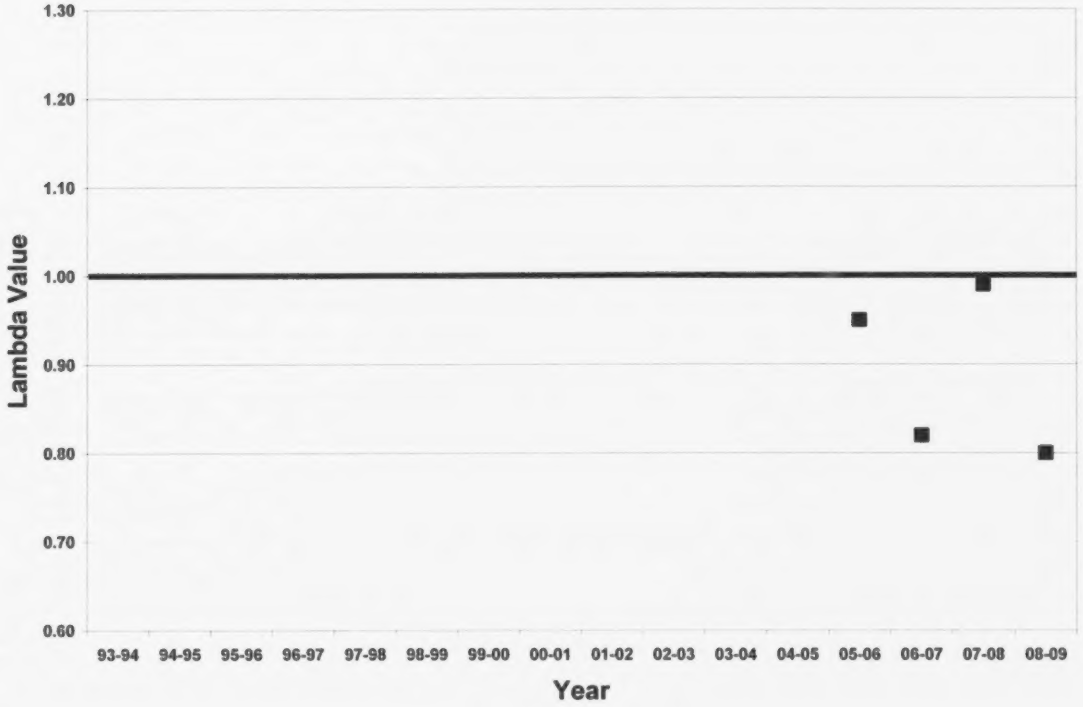

Figure 14(a). Annual population growth rate (lambda; λ) for the adult female component of the Bistcho caribou population. Lambda values of 1.0 indicate population stability. Values greater than 1.0 indicate the magnitude of population growth and values less than 1.0 indicate the magnitude of population decline. Values were calculated using annual estimates of calf recruitment[1] and adult survival[2].

---

[1] Derived from annual estimates of the number of female calves per adult female, based on the proportion of adult females seen with calves during late February/early March population composition surveys (i.e., calves at 9 to 10 months of age). Total number of caribou classified during annual population composition surveys is provided in Appendix 2. Actual population declines may be greater and population increases may be less than calculated lambda values, since population composition surveys do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

[2] Estimates derived from a radio-collared sample of adult female caribou (target of 25 to 30 radio-collared animals per population at the start of each year) between May 1 and April 30 of each year. Survival was estimated using Pollock et al.'s (1989) staggered-entry modification of Kaplan and Meier's (1958) survivorship model (Kaplan-Meier PL Estimator of Survival Rate, Version 2.1, Exeter Software, 47 Route 25A, Setauket, New York, New York, USA, coded by C. J. Krebs - University of British Columbia).

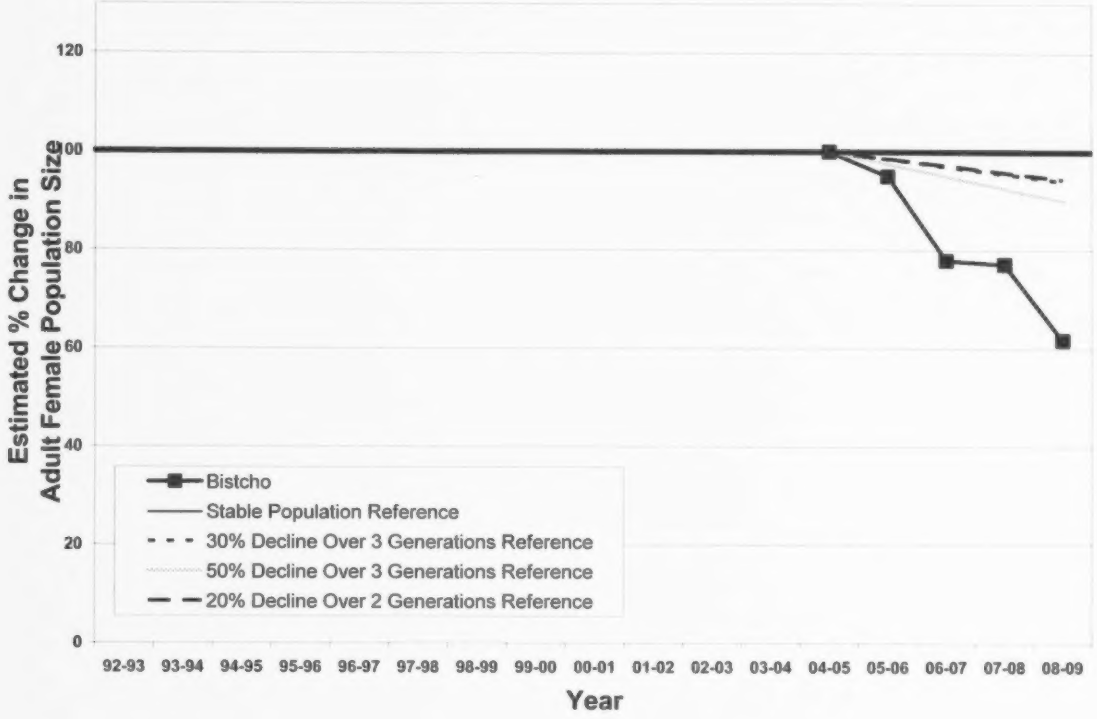

Figure 14(b). Estimated percent change in adult female population size for the Bistcho caribou population. Values were calculated by applying annual population growth rate estimates (lambda; λ) to the preceding year's adult female population estimate. The population was set at 100% at the beginning of the monitoring period. The 30% and 50% decline reference lines illustrate the slope of theoretical population declines of 30% and 50% over 20 years (i.e., 3 caribou generations, based on an average female age of 6.9 years; Fuller and Keith 1981), assuming a constant rate of decline. The 20% decline reference line gives the slope of a theoretical population decline of 20% over 14 years (i.e., 2 caribou generations). Actual population declines may be greater and population increases may be less than shown, since annual lambda estimates are based on population composition surveys which do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

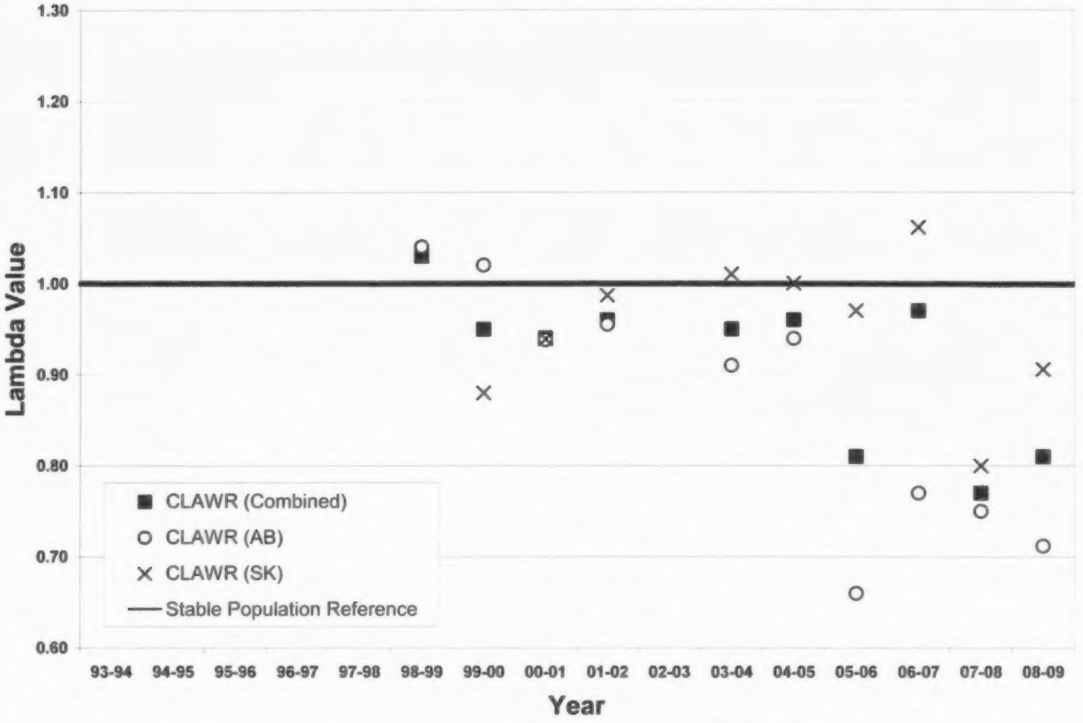

Figure 15(a). Annual population growth rate (lambda; λ) for the adult female component of the Cold Lake caribou population. Lambda values of 1.0 indicate population stability. Values greater than 1.0 indicate the magnitude of population growth and values less than 1.0 indicate the magnitude of population decline. Values were calculated using annual estimates of calf recruitment[1] and adult survival[2]. Monitoring data have been collected separately for segments of this population occurring on the Saskatchewan (SK) and Alberta (AB) portions of the Cold Lake Air Weapons Range (CLAWR), in an attempt to compare caribou vital rates for parts of the range that initially had higher (AB) and lower (SK) levels of industrial development.

[1] Derived from annual estimates of the number of female calves per adult female, based on the proportion of adult females seen with calves during late February/early March population composition surveys (i.e., calves at 9 to 10 months of age). Total number of caribou classified during annual population composition surveys is provided in Appendix 2. Actual population declines may be greater and population increases may be less than calculated lambda values, since population composition surveys do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

2 Estimates derived from a radio-collared sample of adult female caribou (target of 25 to 30 radio-collared animals per population at the start of each year) between May 1 and April 30 of each year. Survival was estimated using Pollock et al.'s (1989) staggered-entry modification of Kaplan and Meier's (1958) survivorship model (Kaplan-Meier PL Estimator of Survival Rate, Version 2.1, Exeter Software, 47 Route 25A, Setauket, New York, New York, USA, coded by C. J. Krebs - University of British Columbia).

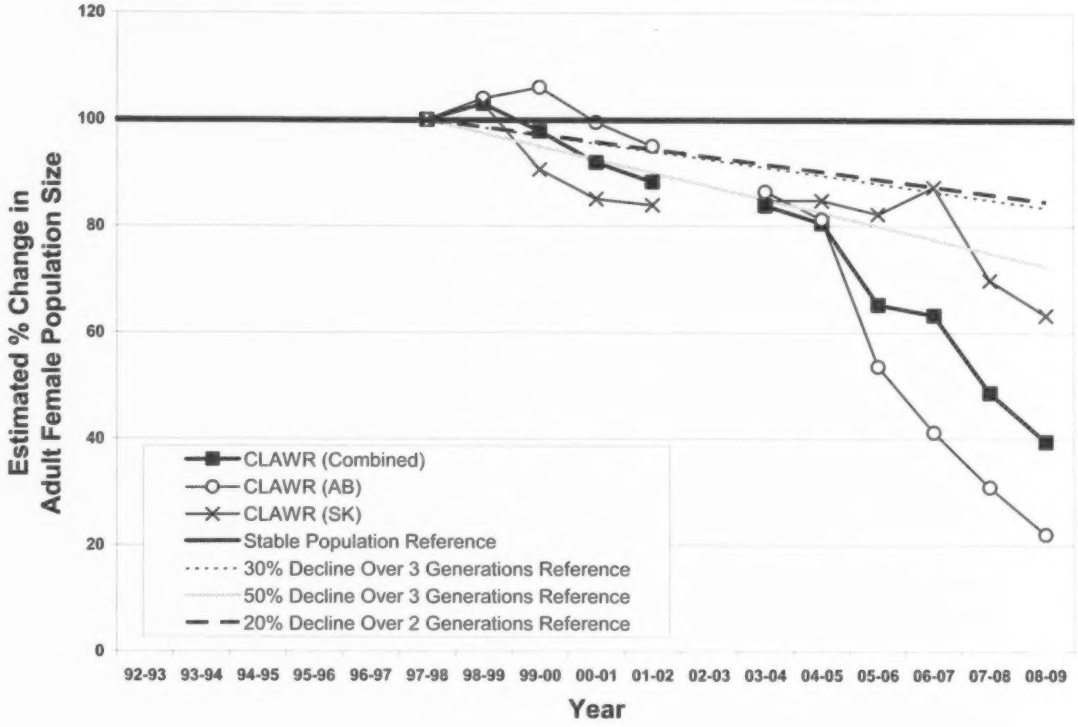

Figure 15(b). Estimated percent change in adult female population size for the Cold Lake caribou population. Values were calculated by applying annual population growth rate estimates (lambda; λ) to the preceding year's adult female population estimate. The population was set at 100% at the beginning of the monitoring period. The 30% and 50% decline reference lines illustrate the slope of theoretical population declines of 30% and 50% over 20 years (i.e., 3 caribou generations, based on an average female age of 6.9 years; Fuller and Keith 1981), assuming a constant rate of decline. The 20% decline reference line gives the slope of a theoretical population decline of 20% over 14 years (i.e., 2 caribou generations). Actual population declines may be greater and population increases may be less than shown, since annual lambda estimates are based on population composition surveys which do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population. Monitoring data have been collected separately for segments of this population occurring on the Saskatchewan (SK) and Alberta (AB) portions of the Cold Lake Air Weapons Range (CLAWR), in an attempt to compare caribou vital rates for parts of the range that initially had higher (AB) and lower (SK) levels of industrial development. Note: A population growth rate estimate was not available for 2002-03; no percent change in population size was assigned for 2002-03, relative to 2001-02.

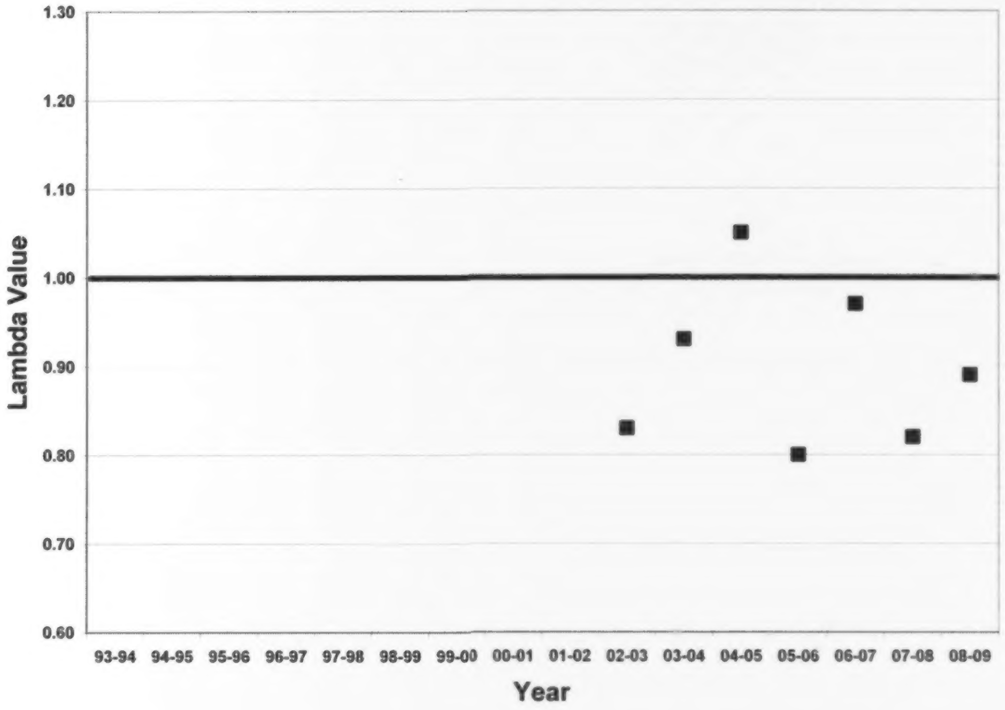

Figure 16(a). Annual population growth rate (lambda; λ) for the adult female component of the Chinchaga caribou population. Lambda values of 1.0 indicate population stability. Values greater than 1.0 indicate the magnitude of population growth and values less than 1.0 indicate the magnitude of population decline. Values were calculated using annual estimates of calf recruitment[1] and adult survival[2].

[1] Derived from annual estimates of the number of female calves per adult female, based on the proportion of adult females seen with calves during late February/early March population composition surveys (i.e., calves at 9 to 10 months of age). Total number of caribou classified during annual population composition surveys is provided in Appendix 2. Actual population declines may be greater and population increases may be less than calculated lambda values, since population composition surveys do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

[2] Estimates derived from a radio-collared sample of adult female caribou (target of 25 to 30 radio-collared animals per population at the start of each year) between May 1 and April 30 of each year. Survival was estimated using Pollock et al.'s (1989) staggered-entry modification of Kaplan and Meier's (1958) survivorship model (Kaplan-Meier PL Estimator of Survival Rate, Version 2.1, Exeter Software, 47 Route 25A, Setauket, New York, New York, USA, coded by C. J. Krebs - University of British Columbia).

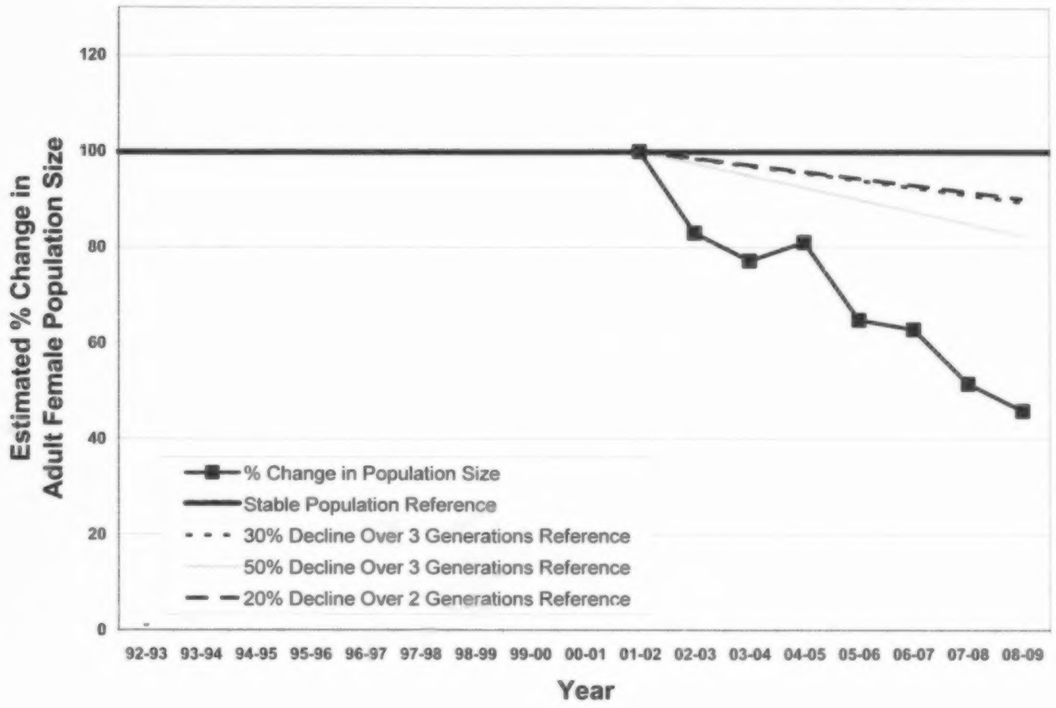

Figure 16(b). Estimated percent change in adult female population size for the Chinchaga caribou population. Values were calculated by applying annual population growth rate estimates (lambda; λ) to the preceding year's adult female population estimate. The population was set at 100% at the beginning of the monitoring period. The 30% and 50% decline reference lines illustrate the slope of theoretical population declines of 30% and 50% over 20 years (i.e., 3 caribou generations, based on an average female age of 6.9 years; Fuller and Keith 1981), assuming a constant rate of decline. The 20% decline reference line gives the slope of a theoretical population decline of 20% over 14 years (i.e., 2 caribou generations). Actual population declines may be greater and population increases may be less than shown, since annual lambda estimates are based on population composition surveys which do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

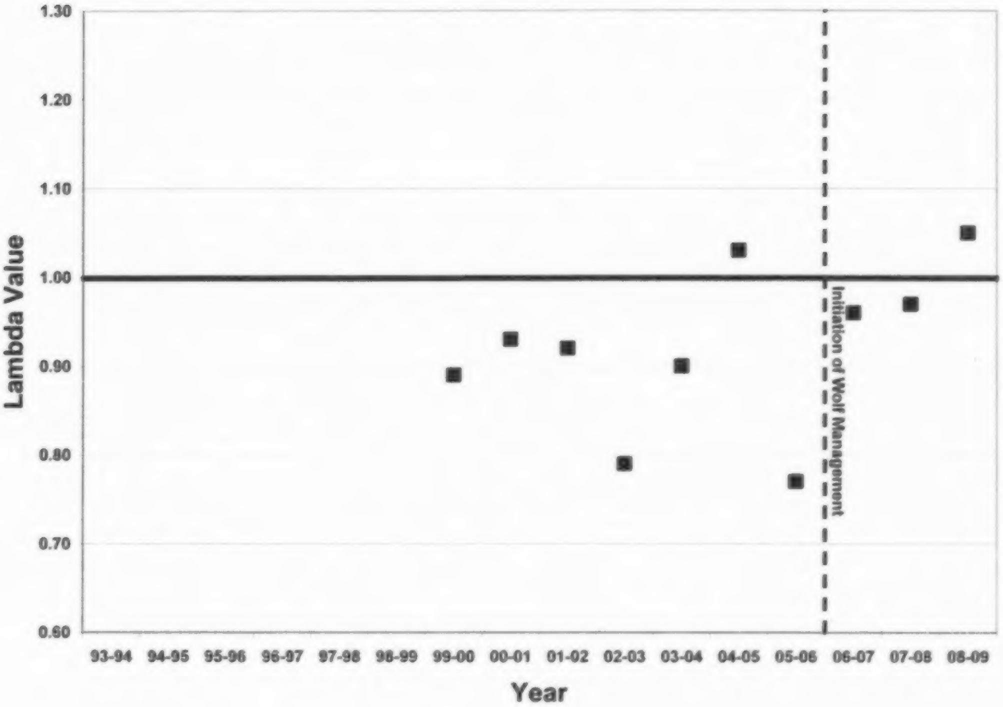

Figure 17(a). Annual population growth rate (lambda; λ) for the adult female component of the Little Smoky caribou population. Lambda values of 1.0 indicate population stability. Values greater than 1.0 indicate the magnitude of population growth and values less than 1.0 indicate the magnitude of population decline. Values were calculated using annual estimates of calf recruitment[1] and adult survival[2].

[1] Derived from annual estimates of the number of female calves per adult female, based on the proportion of adult females seen with calves during late February/early March population composition surveys (i.e., calves at 9 to 10 months of age). Total number of caribou classified during annual population composition surveys is provided in Appendix 2. Actual population declines may be greater and population increases may be less than calculated lambda values, since population composition surveys do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

[2] Estimates derived from a radio-collared sample of adult female caribou (target of 25 to 30 radio-collared animals per population at the start of each year) between May 1 and April 30 of each year. Survival was estimated using Pollock et al.'s (1989) staggered-entry modification of Kaplan and Meier's (1958) survivorship model (Kaplan-Meier PL Estimator of Survival Rate, Version 2.1, Exeter Software, 47 Route 25A, Setauket, New York, New York, USA, coded by C. J. Krebs - University of British Columbia).

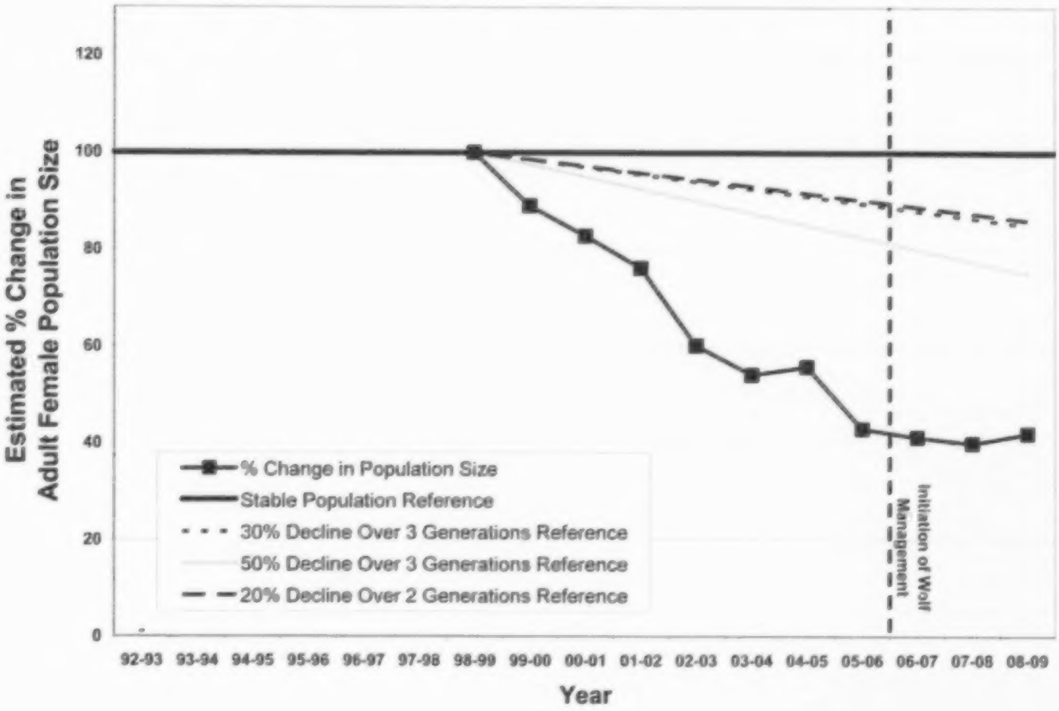

Figure 17(b). Estimated percent change in adult female population size for the Little Smoky caribou population. Values were calculated by applying annual population growth rate estimates (lambda; λ) to the preceding year's adult female population estimate. The population was set at 100% at the beginning of the monitoring period. The 30% and 50% decline reference lines illustrate the slope of theoretical population declines of 30% and 50% over 20 years (i.e., 3 caribou generations, based on an average female age of 6.9 years; Fuller and Keith 1981), assuming a constant rate of decline. The 20% decline reference line gives the slope of a theoretical population decline of 20% over 14 years (i.e., 2 caribou generations). Actual population declines may be greater and population increases may be less than shown, since annual lambda estimates are based on population composition surveys which do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

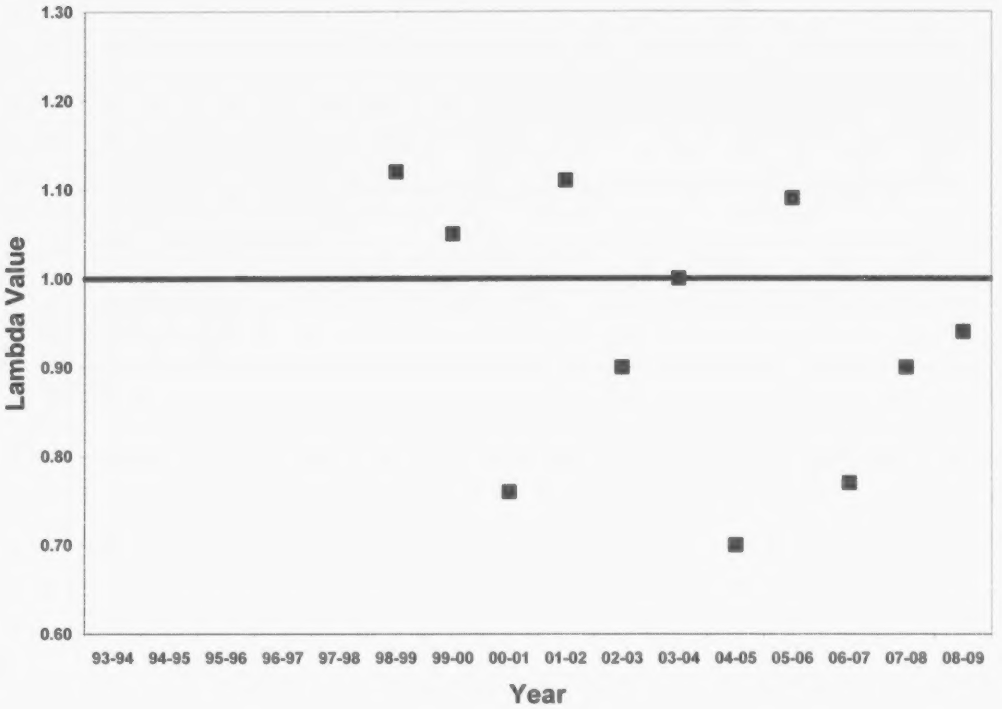

Figure 18(a). Annual population growth rate (lambda; λ) for the adult female component of the Redrock-Prairie Creek caribou population. Lambda values of 1.0 indicate population stability. Values greater than 1.0 indicate the magnitude of population growth and values less than 1.0 indicate the magnitude of population decline. Values were calculated using annual estimates of calf recruitment[1] and adult survival[2].

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[1] Derived from annual estimates of the number of female calves per adult female, based on the proportion of adult females seen with calves during late February/early March population composition surveys (i.e., calves at 9 to 10 months of age). Total number of caribou classified during annual population composition surveys is provided in Appendix 2. Actual population declines may be greater and population increases may be less than calculated lambda values, since population composition surveys do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

[2] Estimates derived from a radio-collared sample of adult female caribou (target of 25 to 30 radio-collared animals per population at the start of each year) between May 1 and April 30 of each year. Survival was estimated using Pollock et al.'s (1989) staggered-entry modification of Kaplan and Meier's (1958) survivorship model (Kaplan-Meier PL Estimator of Survival Rate, Version 2.1, Exeter Software, 47 Route 25A, Setauket, New York, New York, USA, coded by C. J. Krebs - University of British Columbia).

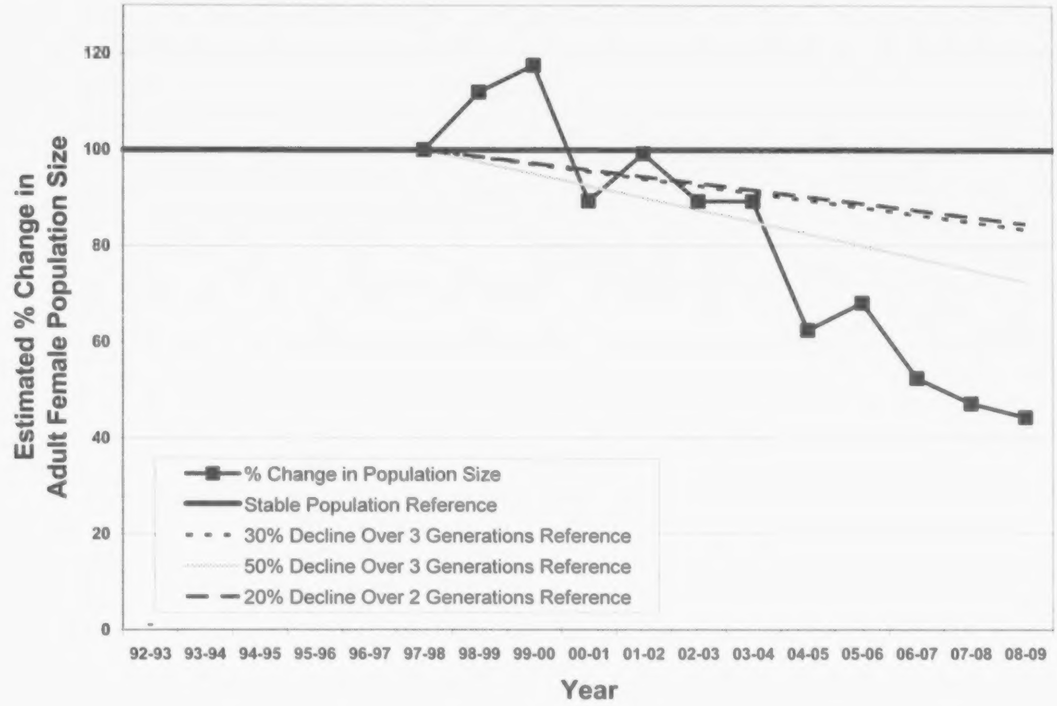

Figure 18(b). Estimated percent change in adult female population size for the Redrock-Prairie Creek caribou population. Values were calculated by applying annual population growth rate estimates (lambda; λ) to the preceding year's adult female population estimate. The population was set at 100% at the beginning of the monitoring period. The 30% and 50% decline reference lines illustrate the slope of theoretical population declines of 30% and 50% over 20 years (i.e., 3 caribou generations, based on an average female age of 6.9 years; Fuller and Keith 1981), assuming a constant rate of decline. The 20% decline reference line gives the slope of a theoretical population decline of 20% over 14 years (i.e., 2 caribou generations). Actual population declines may be greater and population increases may be less than shown, since annual lambda estimates are based on population composition surveys which do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

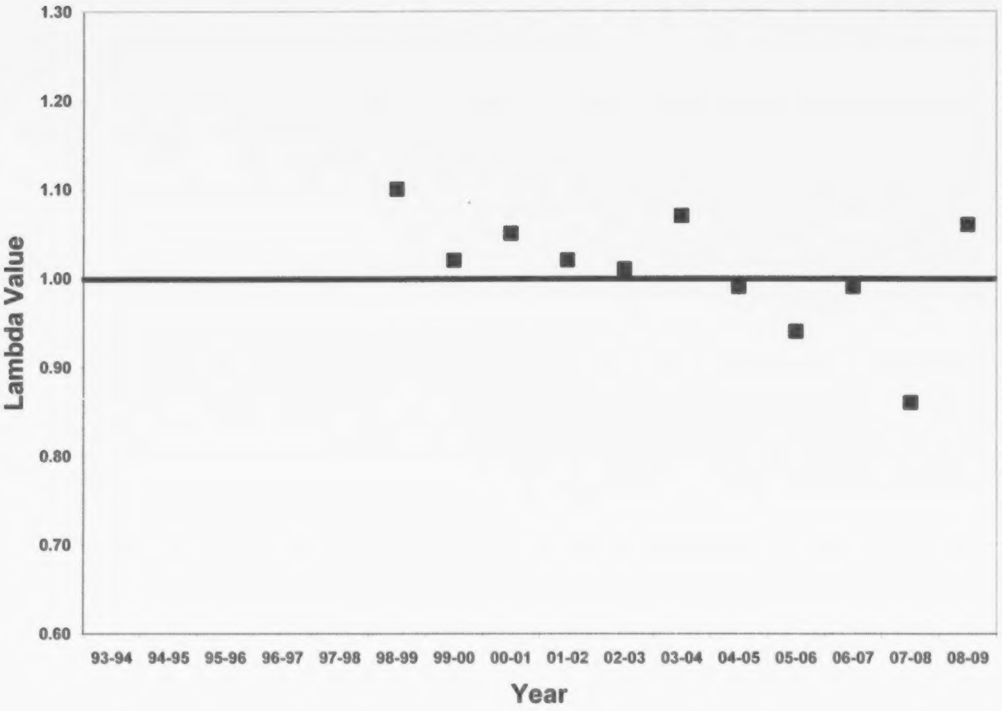

Figure 19(a). Annual population growth rate (lambda; λ) for the adult female component of the A La Peche caribou population. Lambda values of 1.0 indicate population stability. Values greater than 1.0 indicate the magnitude of population growth and values less than 1.0 indicate the magnitude of population decline. Values were calculated using annual estimates of calf recruitment[1] and adult survival[2].

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[1] Derived from annual estimates of the number of female calves per adult female, based on the proportion of adult females seen with calves during late February/early March population composition surveys (i.e., calves at 9 to 10 months of age). Total number of caribou classified during annual population composition surveys is provided in Appendix 2. Actual population declines may be greater and population increases may be less than calculated lambda values, since population composition surveys do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

[2] Estimates derived from a radio-collared sample of adult female caribou (target of 25 to 30 radio-collared animals per population at the start of each year) between May 1 and April 30 of each year. Survival was estimated using Pollock et al.'s (1989) staggered-entry modification of Kaplan and Meier's (1958) survivorship model (Kaplan-Meier PL Estimator of Survival Rate, Version 2.1, Exeter Software, 47 Route 25A, Setauket, New York, New York, USA, coded by C. J. Krebs - University of British Columbia).

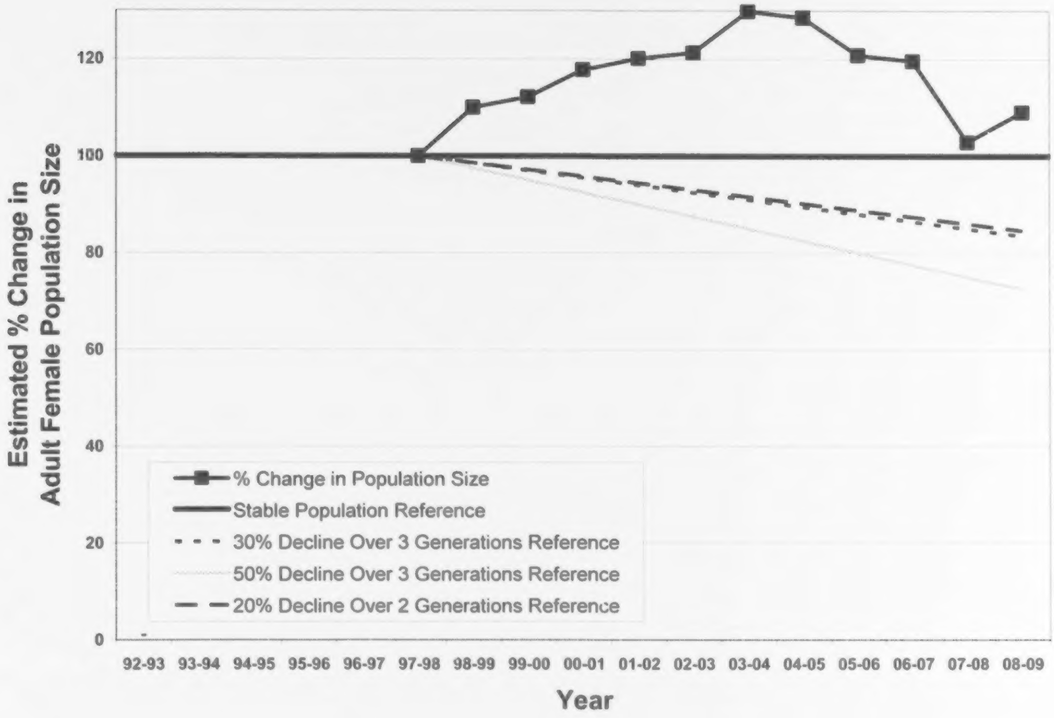

Figure 19(b). Estimated percent change in adult female population size for the A La Peche caribou population. Values were calculated by applying annual population growth rate estimates (lambda; λ) to the preceding year's adult female population estimate. The population was set at 100% at the beginning of the monitoring period. The 30% and 50% decline reference lines illustrate the slope of theoretical population declines of 30% and 50% over 20 years (i.e., 3 caribou generations, based on an average female age of 6.9 years; Fuller and Keith 1981), assuming a constant rate of decline. The 20% decline reference line gives the slope of a theoretical population decline of 20% over 14 years (i.e., 2 caribou generations). Actual population declines may be greater and population increases may be less than shown, since annual lambda estimates are based on population composition surveys which do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

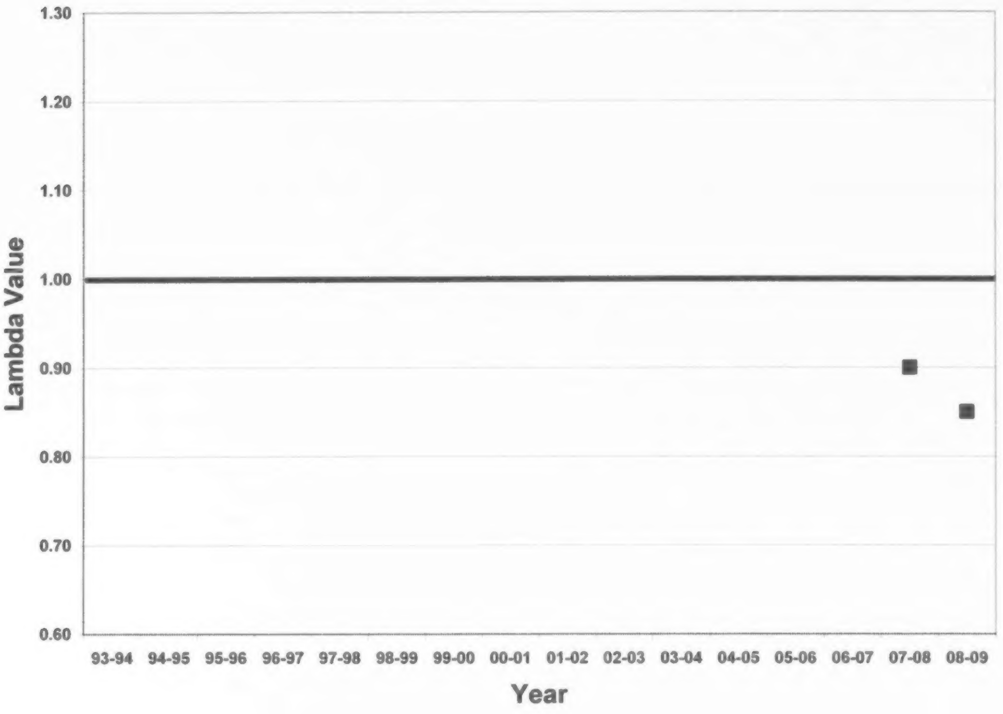

Figure 20(a). Annual population growth rate (lambda; λ) for the adult female component of the Narraway caribou population. Lambda values of 1.0 indicate population stability. Values greater than 1.0 indicate the magnitude of population growth and values less than 1.0 indicate the magnitude of population decline. Values were calculated using annual estimates of calf recruitment[1] and adult survival[2].

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[1] Derived from annual estimates of the number of female calves per adult female, based on the proportion of adult females seen with calves during late February/early March population composition surveys (i.e., calves at 9 to 10 months of age). Total number of caribou classified during annual population composition surveys is provided in Appendix 2. Actual population declines may be greater and population increases may be less than calculated lambda values, since population composition surveys do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

[2] Estimates derived from a radio-collared sample of adult female caribou (target of 25 to 30 radio-collared animals per population at the start of each year) between May 1 and April 30 of each year. Survival was estimated using Pollock et al.'s (1989) staggered-entry modification of Kaplan and Meier's (1958) survivorship model (Kaplan-Meier PL Estimator of Survival Rate, Version 2.1, Exeter Software, 47 Route 25A, Setauket, New York, New York, USA, coded by C. J. Krebs - University of British Columbia).

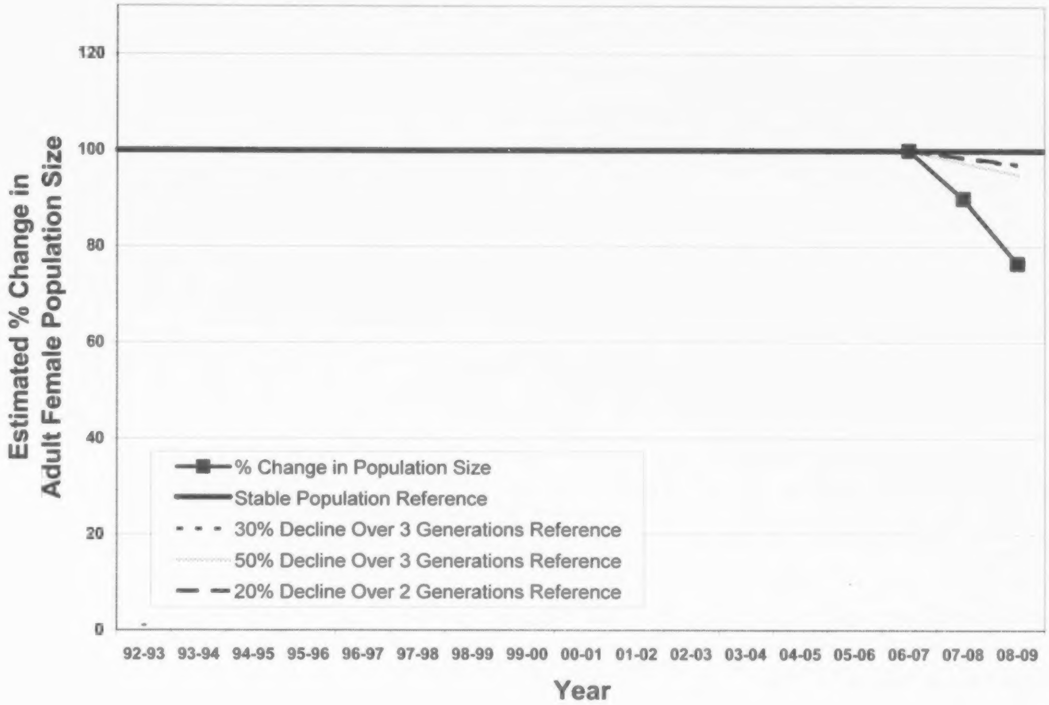

Figure 20(b). Estimated percent change in adult female population size for the Narraway caribou population. Values were calculated by applying annual population growth rate estimates (lambda; λ) to the preceding year's adult female population estimate. The population was set at 100% at the beginning of the monitoring period. The 30% and 50% decline reference lines illustrate the slope of theoretical population declines of 30% and 50% over 20 years (i.e., 3 caribou generations, based on an average female age of 6.9 years; Fuller and Keith 1981), assuming a constant rate of decline. The 20% decline reference line gives the slope of a theoretical population decline of 20% over 14 years (i.e., 2 caribou generations). Actual population declines may be greater and population increases may be less than shown, since annual lambda estimates are based on population composition surveys which do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

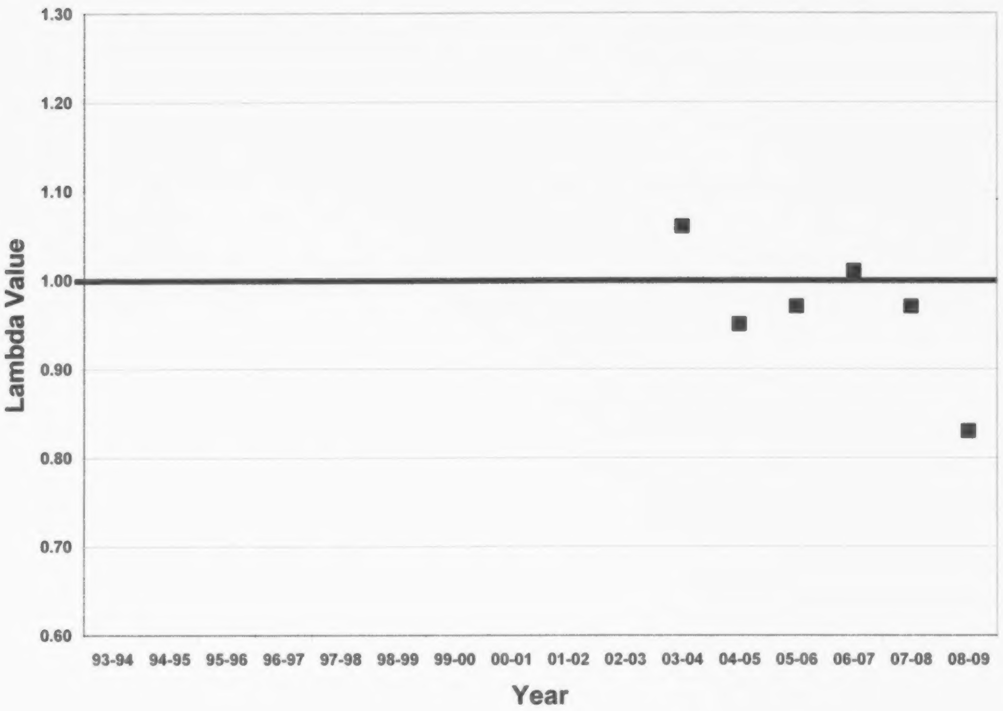

Figure 21(a). Annual population growth rate (lambda; λ) for the adult female component of the Jasper caribou population. Lambda values of 1.0 indicate population stability. Values greater than 1.0 indicate the magnitude of population growth and values less than 1.0 indicate the magnitude of population decline. Values were calculated using annual estimates of calf recruitment[1] and adult survival[2].

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[1] Derived from annual estimates of the number of female calves per adult female, based on the proportion of adult females seen with calves during late February/early March population composition surveys (i.e., calves at 9 to 10 months of age). Total number of caribou classified during annual population composition surveys is provided in Appendix 2. Actual population declines may be greater and population increases may be less than calculated lambda values, since population composition surveys do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

[2] Estimates derived from a radio-collared sample of adult female caribou (target of 25 to 30 radio-collared animals per population at the start of each year) between June 1 and May 31 of each year. Survival was estimated using Pollock et al.'s (1989) staggered-entry modification of Kaplan and Meier's (1958) survivorship model (Kaplan-Meier PL Estimator of Survival Rate, Version 2.1, Exeter Software, 47 Route 25A, Setauket, New York, New York, USA, coded by C. J. Krebs - University of British Columbia).

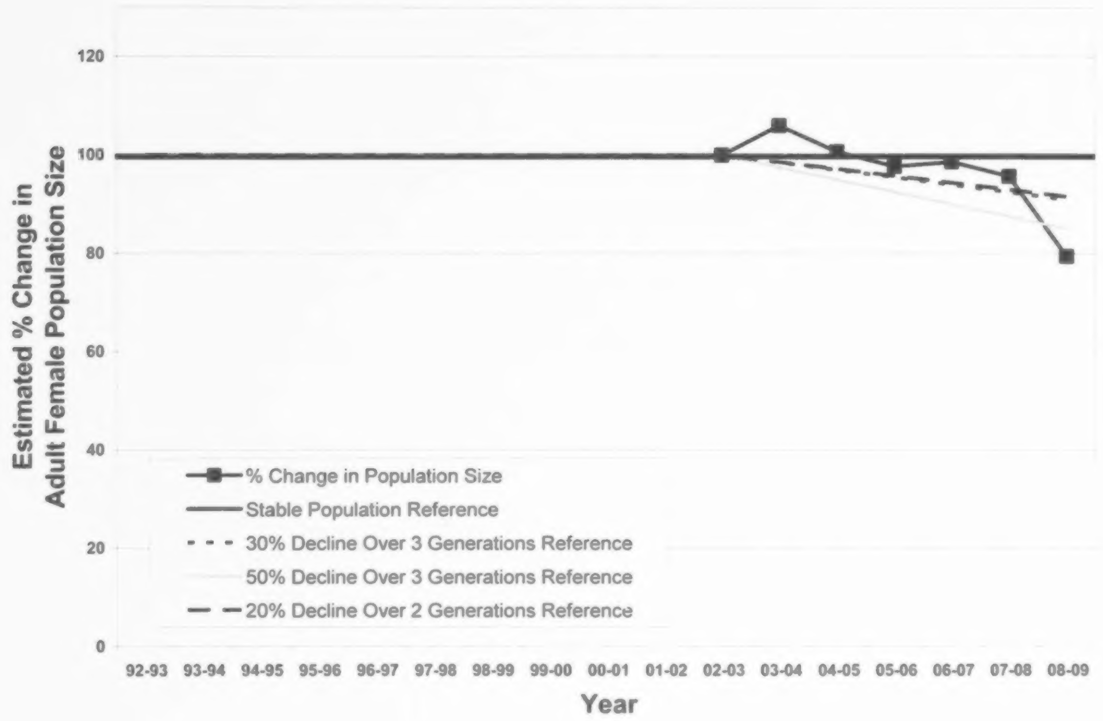

Figure 21(b). Estimated percent change in adult female population size for the Jasper caribou population. Values were calculated by applying annual population growth rate estimates (lambda; λ) to the preceding year's adult female population estimate. The population was set at 100% at the beginning of the monitoring period. The 30% and 50% decline reference lines illustrate the slope of theoretical population declines of 30% and 50% over 20 years (i.e., 3 caribou generations, based on an average female age of 6.9 years; Fuller and Keith 1981), assuming a constant rate of decline. The 20% decline reference line gives the slope of a theoretical population decline of 20% over 14 years (i.e., 2 caribou generations). Actual population declines may be greater and population increases may be less than shown, since annual lambda estimates are based on population composition surveys which do not capture all calf and juvenile caribou mortality prior to their recruitment to the breeding population.

component for each caribou population since monitoring of the rate of population change (lambda; λ) began, based on the cumulative consequences of annual population rate of change (lambda; λ) estimates. As noted above, lambda values are provided without a measure of associated variance or error. Any error in annual lambda (λ) estimates will tend to amplify over the years of data collection shown on Figures 9(b) to 21(b). Figures 9(b) to 21(b) are not intended to provide a precise estimate of change in caribou populations, but rather to indicate the general implications of annual lambda (λ) estimates.

Most monitored caribou populations in Alberta, composing approximately 70% (see Table 9b) of the caribou currently estimated to occur in the province and occupying 83% of the total current provincial caribou range area, are now demonstrating a consistent pattern of decline in the adult female component of their populations. This population decline is evident for the West Side Athabasca River, East Side Athabasca River, Red Earth, Caribou Mountains, Bistcho, Cold Lake, Chinchaga, Redrock-Prairie Creek, and (based on two years of data) Narraway populations. In addition, the Jasper woodland caribou population has demonstrated approximate population stability in the recent past; however, data from 2007/08 and 2008/09 indicate a significant population decline, and based on surveys in 2009 very few caribou now remain in each of the Brazeau (sighting of 9 caribou in total) and Maligne (sighting of 4 caribou in total) caribou subpopulations in Jasper (Parks Canada 2009). The Little Smoky population has undergone a substantial female caribou population decline during the period of monitoring; however, annual lambda (λ) values for this population now indicate approximate population stability in response to a wolf population reduction program[6] initiated by the Alberta Government beginning in late winter of 2005/06. It is possible that the current stability of the A La Peche population is also due to wolf management on a portion of the A La Peche range and the adjacent Little Smoky range, and potentially also in response to the partial abandonment of traditional foothills winter range (i.e., abandonment of range areas that now have increased potential for caribou mortality related to habitat change). The Little Smoky and A La Peche populations together contain approximately 8% of all caribou in the province, and occupy 6% of total current provincial caribou range area. Based on two years of monitoring data, the Yates population (containing approximately 12% of all caribou in the province, and occupying 3% of total current provincial caribou range area; however, note that the Yates caribou population estimate includes animals that also occur in the Northwest Territories) appears to be stable; this is the only monitored population in the province that is demonstrating population stability, in the absence of predator management.

Comparing current information to results reported in the first edition of the *Status of Woodland Caribou in Alberta* (Dzus 2001) indicates that the pattern of caribou population declines is now more pronounced for the East Side Athabasca River, Red Earth, Caribou Mountains, and Cold Lake populations. Also, the population stability reported in the first edition for West Side Athabasca River and Redrock-Prairie Creek has now changed to population decline. The first edition of this status report described a substantial decline in the A La Peche population during the early to middle 1990s as a result of caribou mortality from vehicle collisions on Highway 40. This second edition of the *Status of Woodland Caribou in Alberta* describes the rate of A La Peche population change (λ) beginning in 1998/99, when more intensive data collection efforts began. More caribou populations are now being monitored for calf and adult female survival in comparison to results reported in Dzus (2001). In the first edition, monitoring data were not available for Yates, Bistcho, Chinchaga, Narraway, and Jasper; current data indicate that the Bistcho, Chinchaga, Narraway, and Jasper (based on the last two years of data) populations are declining.

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[6] The need for wolf management to avoid extirpation of the Little Smoky caribou population was described in the approved provincial woodland caribou recovery plan (Alberta Woodland Caribou Recovery Team 2005) and enabled by the Alberta provincial management plan for wolves (Alberta Forestry, Lands and Wildlife 1991b).

Despite the absence of reliable population enumeration techniques, there have been several attempts in the past to estimate the total number of woodland caribou in Alberta. These estimates have been typically presented as ranges of values and were based on guesses or professional judgment only. Edmonds (1986) estimated 1324 to 1868 woodland caribou in Alberta and later updated this estimate to 3300 (Edmonds 1991). Ferguson and Gauthier (1992) reported 3000 to 3500. The Alberta Woodland Caribou Conservation Strategy Development Committee (1996) estimated 3600 to 6700 caribou in the province. Contrary to apparent increases in population estimates since 1986, most authorities contend that since 1900 there has been a significant decline in the number and size of caribou populations in Alberta and amount of occupied range (e.g., Brown and Hobson 1998, Edmonds and Bloomfield 1984). Recent increases in caribou population estimates are the result of increases in survey efforts and improvements in our understanding of caribou distribution in Alberta. Bradshaw and Hebert (1996) reviewed purported long-term declines in woodland caribou numbers and distribution in Alberta, and described their belief that there are no reliable data to support or refute the general perception of population declines in northern Alberta. There now exists, however, considerable information indicating an ongoing pattern of declines in provincial caribou populations and distribution.

Table 9a provides population size estimates for individual caribou populations, developed during or prior to 2005/06 by the Alberta Government. These estimates were generated using professional judgment, guided by minimum total counts of caribou observed during late-winter population composition surveys (Appendix 2). With the exception of estimates for the Jasper caribou population, the estimates of woodland caribou population sizes are not precise and should be used with caution; these estimates are provided for general reference only. Table 9b is an attempt to update the population size estimates, in consideration of recent annual population lambda estimates, with an estimated total of 2074–2315 boreal caribou and 534 mountain caribou, for a total of 2608–2849 woodland caribou in Alberta. In addition, Table 9b provides the estimated number of mature caribou (i.e., >2 years of age), with 1813–2022 mature boreal caribou and 451 mature mountain caribou, giving a total of 2264–2473 mature caribou in Alberta.

2. Other Areas - Not all jurisdictions have intensive widespread programs to collect woodland caribou mortality and recruitment data and calculate annual population change (λ) rates in a manner similar to efforts in Alberta (e.g., see Environment Canada 2007). Also, the methods used in other jurisdictions for determining woodland caribou population size range from guesses, to extrapolations in relation to available habitat, to structured aerial surveys. A summary of boreal caribou population estimates from all provinces and territories provided a total estimate of 31 552–39 041 woodland caribou (57 populations) within the Boreal National Ecological Area (Environment Canada 2007). There are an estimated 8181 woodland caribou (35 populations) within the Southern Mountain National Ecological Area (mountain ecotype populations plus Little Smoky from Table 9b; British Columbia Ministry of Environment unpubl. data). As noted above for Alberta, these national woodland caribou population estimates have been generated primarily using professional judgment, guided in some cases by minimum total counts of caribou observed during aerial surveys or other field studies.

Table 9(a). Estimated population size[1] of woodland caribou populations in Alberta. (Note: Estimates provided below were developed during, or prior to, 2005/2006).

Caribou Population	Estimated population size	Comments
Boreal Ecotype		
West Side Athabasca River	300–400	
East Side Athabasca River	150–250	
Yates	300	Range shared with N.W.T.
Red Earth	250–300	Small part of range extends into Wood Buffalo National Park
Caribou Mountains	400–500	Small part of range extends into Wood Buffalo National Park
Bistcho	300	Range shared with N.W.T. and B.C.
Cold Lake	100–150	Range shared with Saskatchewan and Cold Lake Air Weapons Range
Chinchaga	250–300	Range shared with B.C.
Slave Lake	75	
Nipisi	60–70	
Richardson	Unknown	
Little Smoky	80	
Sub Total	**2265–2725**	

Mountain Ecotype		
Redrock-Prairie Creek	325	Summer range extends into B.C.
A La Peche	150	Summer range extends into B.C.
Narraway	100	Summer range entirely in B.C. Winter range shared with B.C.
Jasper	87	Population now restricted to Jasper National Park and immediately adjacent parts of British Columbia.
Banff	0	Extirpated in 2009
Sub Total	**662**	
Total	**2927–3387**	

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[1] Generated primarily using professional judgment, guided by minimum total counts of caribou observed during late-winter population composition surveys. With the exception of estimates for the Jasper caribou population, these estimates are not precise and should be used with caution; they are provided for general reference only. Population size estimates with confidence intervals have been developed for the Jasper caribou population using mark-resight techniques; use of these techniques has been possible in Jasper because of the typical occurrence of this caribou population in open alpine areas.

Table 9(b). Estimated population size and number of mature individuals for woodland caribou populations in Alberta, adjusted to May 2009.

Caribou Population	Estimated caribou population size[1]	Estimated number of mature caribou in the population[2]
Boreal Ecotype		
West Side Athabasca River	204–272	174–231
East Side Athabasca River	90–150	78–130
Yates	350[3]	299
Red Earth	172–206	156–186
Caribou Mountains	315–394	281–351
Bistcho	195	167
Cold Lake[4]	150[3]	140
Chinchaga	250[3]	229
Slave Lake & Nipisi (combined)	120[3]	109
Richardson	150[3]	115[5]
Little Smoky	78	65
Sub Total	**2074–2315**	**1813–2022**

Mountain Ecotype		
Redrock-Prairie Creek	212	178
A La Peche	135	116
Narraway	100[3]	90
Jasper	87[6]	67
Banff	0[6]	0
Sub Total	**534**	**451**
Total	**2608–2849**	**2264–2473**

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[1] Based on population size estimates provided in Table 9(a); adjusted using available population lambda estimates for 2006-07 to 2008-09.

[2] Calculated using the estimated caribou population size adjusted for the estimated proportion of sub-adult caribou (i.e., < 2 years old) in the population. Proportion of calves (i.e., animals approaching 1 year of age) per adult female was derived from 2008/09 late-winter population composition survey results, and proportion of caribou approaching 2 years of age was from 2007/08 late-winter population composition survey results. Assumes equal ratio of adult males to adult females, and that mortality rates for the caribou cohort approaching 2 years of age are equivalent to adult caribou mortality rates.

[3] Based on 2008-09 population composition survey results. The Yates population estimates include animals that occur in the Northwest Territories.

[4] Alberta population only.

[5] No population composition survey was completed in 2007/08; composition survey results (i.e., proportion of calves) for 2008/09 was used to assign the estimated proportion of caribou approaching 2 years of age.

[6] Parks Canada estimate.

LIMITING FACTORS

Limiting factors can be discussed in a strict scientific sense, or in more general terms. From the scientific perspective of population ecology, a limiting factor is anything that has a measurable negative effect on the population's rate of change (Boutin 1992, Messier 1991, Sinclair 1989). In a broader context, a limiting factor may be considered anything that negatively affects either population dynamics or habitat suitability. Changes in habitat quality or quantity may indirectly affect survival or reproduction of an animal and, as such, the two views of limiting factors are inter-related. In population ecology, a number of factors may be limiting at the same time (Watson and Moss 1970). Woodland caribou naturally exist at low density and have low reproductive output, and therefore will be slower to recover from the effects of an array of limiting factors (either alone or in concert) than species such as deer, elk or moose, which naturally maintain higher population densities and are more productive.

The following subsections discuss limiting factors (in both scientific and broader contexts) that can affect woodland caribou in Alberta. Although each limiting factor is discussed separately, interactions between factors contribute to overall effects on caribou populations and habitats.

1. Predation - Predation is acknowledged to be the main proximate limiting factor for woodland caribou throughout Canada (Bergerud and Elliot 1986, Courtois et al. 2007, McLoughlin et al. 2003, Rettie and Messier 1998, Schaefer et al. 1999, Thomas and Gray 2002, Wittmer et al. 2005a, 2005b). Woodland caribou that are able to spatially separate themselves from other ungulate prey are less susceptible to predation (Bergerud and Page 1987, Seip 1992). Caribou spacing strategies include seasonal migrations (i.e., mountain caribou; Edmonds 1988, Edmonds and Smith 1991) and distributing themselves at low densities across very large range areas (i.e., both mountain and boreal caribou; Bergerud 1980, Bergerud et al. 1984) that contain lower densities of alternate prey and hence lower densities of predators. Boreal caribou in northern Alberta select fen/bog complexes, whereas moose and wolves tend to select well-drained habitat, resulting in spatial separation (James et al. 2004). In winter, predation pressure and risk were found to be higher in well-drained upland habitat than in fen/bog complexes (James et al. 2004, McLoughlin et al. 2005).

Various factors, such as anthropogenic habitat change, can affect the vulnerability of caribou to predation. Caribou have co-existed with natural habitat change (primarily forest fires) and wolves for thousands of years; however, evidence indicates that recent human alterations of caribou habitats have increased wolf predation of caribou by making it more difficult for caribou to minimize overlap with wolves. Information indicates that anthropogenic disturbance can lead to increased wolf predation on caribou by 1) driving increases in the density of other prey species and thereby increasing wolf density; 2) drawing wolves into caribou range (and possibly increasing wolf hunting efficiency while in caribou range); and 3) reducing the availability of large, intact patches of habitat where caribou can space themselves out and away from primary prey and wolves. Even a small change in predation pressure can trigger caribou population declines (e.g., Wittmer et al. 2005a, 2007). Moreover, availability of other prey species means that wolves can drive caribou to extirpation with little negative feedback effect on their own populations (i.e., apparent competition; Cumming et al. 1996, Edmonds 1988, Hebblewhite et al. 2007, Holt and Lawton 1994, Mech and Boitani 2003, Messier 1994, Rettie and Messier 2000, James et al. 2004, Wittmer et al. 2005a).

If wolves reach a density of 6.5 wolves/1000 km^2 or more, caribou populations are expected to decline (Bergerud and Elliot 1986; however, Hebblewhite et al. 2007 suggested a threshold of 2.3 to 4.1 wolves/1000 km^2 in their Jasper/Banff-based caribou study). Recent surveys in several caribou ranges suggest that the 6.5/1000 km^2 wolf density threshold has been exceeded in some Alberta caribou ranges (Fish and Wildlife Division unpubl. data; Alberta Caribou Committee unpubl. data; Latham 2009).

Interactions between predation and factors such as weather and climate, habitat alteration from timber harvesting and linear corridors, abundance and distribution of other prey species, and human recreation and other activities are complex. The following subsections include discussions that relate predator-caribou dynamics to other potential limiting factors.

2. Habitat Loss and Alteration - Woodland caribou are typically found in large tracts of mature to old forest that contain lichens; habitat features that can be significantly altered by natural or anthropogenic disturbances. In the past, fire has been the main natural disturbance shaping the vegetation on caribou ranges in Alberta; however, mountain pine beetles have recently become a consideration on caribou ranges in west-central Alberta. The primary anthropogenic disturbances to caribou habitat in Alberta are related to oil and gas exploration and development, forest harvesting, and the construction, maintenance and use of linear features (e.g., roads, seismic lines, pipelines, and power lines) associated with those activities. Peat mining and agricultural development remove caribou habitat on a small number of caribou ranges, but at much lower levels than oil and gas, and forest harvesting.

In the past, some biologists have postulated that the loss of habitat is, on its own, a major limiting factor for caribou populations (Bloomfield 1980a, Edwards 1954). However, McLoughlin et al. (2003) summarize the more contemporary view that habitat disturbances ultimately affect caribou populations by affecting habitat use, movements, and the abundance of predators and other prey; habitat alterations result in excessive predation on caribou. Bergerud (1974) argued that it was not the loss or alteration of habitat that initiated the decline and range recession of caribou in many areas of North America, but rather the secondary effects associated with increased predation.

All anthropogenic and natural habitat alterations in caribou range directly remove caribou habitat (e.g., Edmonds 1988, Smith et al. 2000, Tracz 2005), resulting in smaller, and potentially less contiguous and more isolated habitat patches (e.g., Fahrig 2003). An immediate loss of habitat occurs if forests, and associated lichens, are harvested or significantly reduced. Caribou may be partially or fully displaced from preferred habitat/range areas to other areas with higher predation risk. Alternatively, high levels of human- and/or natural-caused disturbance could eliminate the ability of caribou to exist in some range areas. Additional direct effects can include creating barriers to movements and altering caribou behaviour through removal or reduction of trees for snow interception (Cichowski 2007, Davis and Franzmann 1979, Kelsall et al. 1977, Klein 1982, Schaefer and Pruitt Jr. 1991).

The primary indirect effects of anthropogenic and natural disturbances begin with changes in forest floor and light conditions toward those that favour vegetation species other than lichens. These changes in vegetation can result in increases in deer, elk, and/or moose populations, which thrive on the vegetation typical of young regenerating forests. It is noted, however, that vegetation response to disturbance will depend on site conditions; some areas may not support preferred forage for other ungulates (e.g., very dry sites may not support forage plants because of harsh growing conditions). Increases in other ungulates in relation to increased abundance of young forest lead to increases in wolf numbers (i.e., a numerical response) or changes in the distribution of wolves (and possibly bears), leading to increased predation rates on caribou (Seip 1992). James (1999) indicated that caribou in northeastern Alberta may experience at least an order of magnitude increase in predation rates if populations of other ungulates increase to levels that provide a prey base sufficient to allow wolf occupancy of caribou range throughout the year. This assessment has been supported by Latham (2009) and the caribou population growth information provided in this updated status report.

Habitat disturbance can also reduce habitat quality and result in effective habitat loss as a result of caribou avoidance and reduced use of affected areas. In particular, caribou use of anthropogenic disturbances (e.g., cutblocks, well sites, roads, and seismic lines) and areas around these disturbances has been shown to be significantly less than expected (Dyer et al. 2001, 2002, James and Stuart-Smith 2000, Neufeld 2006, Oberg 2001, Smith et al. 2000, Saher 2005; also see Mahoney and Schaefer 2002, Vistnes and Nellemann 2008). Avoidance of disturbance may be driven by wolf, human, and other predator activities on and near disturbances (Dyer et al. 2001; also see James and Stuart-Smith 2000). For example, Saher (2005) speculated that caribou in the Narraway range did not avoid linear features because of possible low predator abundance, which meant that caribou did not associate seismic lines with predation risk.

True loss of caribou habitat probably occurs only as a result of permanent modifications of the habitat associated with landscape conversion (e.g., forest to agricultural land, as has occurred in some provincial caribou ranges; D. Hervieux pers. comm., D. Moyles pers. comm.). If forests altered by natural or anthropogenic disturbances are allowed to follow a natural path of succession, most habitat loss would be better defined along a gradient of habitat alteration. However, if regenerating forests are subsequently scheduled for timber harvesting or other industrial development activities before they reach an age at which they can sustain caribou, then habitat alteration effectively becomes habitat loss. Timber harvesting can reduce the suitability of caribou habitat for the period of time required for lichens to re-establish (Kranrod 1996).

Fire is the dominant natural factor shaping the boreal forest of Alberta (Rowe and Scotter 1973) and has important implications for caribou populations. In the short term, fire is detrimental to caribou habitat when it removes forest cover and lichens; however, in the long term, fire may be beneficial when it removes competing vegetation and re-creates growing conditions for lichens that are declining in productivity (Klein 1982, Scotter 1970, Schaefer and Pruitt Jr. 1991, Thomas 1998). Terrestrial lichen abundance recovered 40 years after fire disturbance in peatlands in northern Alberta (Dunford et al. 2006), although caribou winter use of burned areas 60 years post-fire is generally low (Dalerum et al. 2007, Joly et al. 2003, Schaefer and Pruitt Jr. 1991, Thomas 1998). Barren-ground caribou were reported to travel up to 25 km through very large burns, but they did not spend much time in them (Thomas 1998). In northern Alberta, boreal caribou did not change home range size or shift home ranges following fire, probably since initial home range sizes were large enough to provide adequate habitat and space for caribou even with fire disturbance (Dalerum et al. 2007). Thomas (1998) suggests that blow-down, thick re-growth, or poor snow conditions in burns rarely create movement barriers to caribou, and that lack of caribou use of burned areas is likely due to a lack of available food. In general, woodland caribou have evolved in the presence of forest fires and have persisted for millennia in the boreal forest with the occurrence of this natural habitat alteration; however, concerns for the persistence of woodland caribou have been raised in relation to the combined effects of forest fire and the recent proliferation of anthropogenic habitat changes (e.g., Sorenson et al. 2008).

In response to mild winter temperatures in recent years, mountain pine beetles are emerging as a disturbance agent in parts of western Alberta. An ongoing study on the effects of the current mountain pine beetle epidemic on terrestrial lichens in west-central British Columbia has documented an initial decline in terrestrial lichen abundance in mountain pine beetle-killed forests as a result of increases in other forest floor vegetation, especially kinnikinnick (*Arctostaphylos uva-ursi*); however, the decline of terrestrial lichen and increase in kinnikinnick has started to level off (Cichowski et al. 2008). Response of dwarf shrubs on different caribou ranges may vary and depend on what dwarf shrubs are present at the time of beetle infestation (Cichowski et al. 2009). A study of caribou habitat use in forests heavily damaged (i.e., grey attack stage; needles have fallen from attacked trees) by mountain pine beetle indicates that caribou are continuing to use their traditional winter range, are continuing to crater for terrestrial lichens in open beetle-killed pine forests, and are foraging on arboreal lichens in all habitats (Cichowski 2009).

Currently, in response to mountain pine beetle control efforts, Alberta government policy (the "Healthy Pine Strategy") is to require forest companies to remove 75% of all pine stands within 20 years (Alberta Sustainable Resource Development 2006). This strategy was predicted to have the greatest potential negative effect to woodland caribou of any of the industrial development scenarios modeled for caribou populations in west-central Alberta (Alberta Caribou Committee 2008).

Forest harvesting on caribou winter range in west-central Alberta is thought to have negatively affected caribou populations (Bjorge 1984, Edmonds and Bloomfield 1984, Edmonds 1988). Through analysis of long-term data sets in west-central Alberta, Smith et al. (2000) documented reductions in caribou distribution, daily movement rates and winter range sizes as timber harvesting progressed. The avoidance of habitats fragmented by logging caused caribou to concentrate in unlogged portions of their winter range. "Ecological compression" of caribou runs counter to their adaptive strategy of remaining at low density within large range areas and could result in increased predation rates. Similarly, Neufeld (2006) found that areas with a large proportion of cutblocks tended to be avoided by caribou and selected by wolves. In addition, wolves used cutblocks proportionately more compared to other habitats (Kuzyk et al. 2004).

In the absence of long-term habitat supply commitments for caribou, including accommodations for caribou in spatial harvest sequences and annual allowable cut levels, timber harvesting in west-central Alberta will not allow for a suitable amount and spatial distribution of appropriate forest age classes to permit long-term caribou persistence (Alberta Caribou Committee 2008). Additionally, it is possible that logging and subsequent silvicultural treatments may not be equivalent to wildfire in creating optimal conditions for the renewal of lichen growth.

Jasper and Banff national parks have experienced little anthropogenic habitat change, in comparison to adjacent industrial landscape areas, yet human-mediated factors are still the most likely cause of caribou decline. Caribou decline in the national parks could be related to the loss of caribou migratory behaviour associated with many land use changes in former foothills wintering habitat. Also, the presence of towns and outlying accommodations within the parks could be providing elk with a partial refuge from predation, resulting in increased wolf populations being supported by unnaturally large elk populations (M. Bradley pers. comm.).

In the boreal regions of Alberta, timber harvesting in black spruce/larch forests is generally not commercially viable at present. Although the caribou found predominately in the peatlands of northern Alberta are not currently at risk from large-scale forestry operations in their habitat, they may be at risk from indirect and edge effects of timber harvesting in upland areas adjacent to peatland complexes (Alberta Caribou Committee 2009). It is noted that some boreal ecotype caribou in Alberta use commercial upland forest (e.g., Little Smoky [Alberta Sustainable Resource Development unpubl. data]; Chinchaga [Hornbeck and Moyles 1995]; Richardson [T. Powell pers. comm.]).

Although the magnitude of change will vary among caribou ranges, there is a strong theoretical, and in some cases empirical, basis for the relationship between timber harvesting in or near caribou range and its subsequent effects on predator-caribou dynamics (e.g., Seip 1992, Messier 1994, Cumming et al. 1996, James 1999).

Extensive oil and gas deposits underlie most caribou ranges in Alberta. Very high levels of petroleum and natural gas exploration and development have taken place on most of Alberta's caribou ranges, and the extent and intensity of this work has accelerated in recent decades (e.g., Schneider 2002). As a consequence of continued industrial use, slow forest regeneration, and/or high levels of recreational vehicle use, much of the habitat change caused by oil and gas development over the last several decades remains in place on many caribou ranges (e.g., Lee and Boutin 2006).

3. Linear Corridors, Human Activity and Effects on Predator Ecology - Fragmentation of habitat by linear corridors (e.g., above- and below-ground pipelines, roads, seismic lines, transmission corridors) and/or forestry cutblocks can have a number of effects on caribou movements, distribution, and survival, such as increased mortality from hunting and poaching; increased mortality from collisions with vehicles; changes in movements and distribution of both predators and prey, including decreased use of areas by caribou; and, increased sensory disturbance of caribou (see the last paragraph in this subsection).

Corridors provide access for humans and predators to penetrate caribou range that formerly was not easily accessible. Although licensed harvest of caribou has not been allowed in Alberta since 1981, the extent of caribou mortality from hunting by aboriginal people, as well as poaching, is largely unknown and probably varies between areas. Some entire groups of caribou in the Chinchaga range are known to have been eliminated by hunting (D. Moyles pers. comm.). During the winter of 2009/2010 at least 30 caribou are known to have been harvested in the Northwest Territories from the trans-boundary Yates caribou population (D. Moyles pers. comm.). For some boreal ecotype caribou populations, hunting may account for at least 15% to 20% of mortality on radio-collared adult caribou (Figure 8). Bradshaw and Hebert (1996) suggested that, theoretically, the lack of predictability in movements of boreal ecotype caribou reduced the risks associated with overhunting. Although this may be true under pre-industrial conditions, the current proliferation of linear corridors is understood to compromise the survival strategies of these animals. Improved access into caribou range as a result of expanding networks of linear corridors could promote further increases in aboriginal and illegal hunting of caribou.

Human use of linear corridors also has the potential to increase traffic collisions with woodland caribou. Vehicle collisions with caribou have been problematic along a section of Highway 40 (south of the town of Grande Cache in west-central Alberta) that bisects the traditional winter range of the A La Peche caribou population. During the winters of 1991/92 and 1992/93, at least 32 caribou were hit on this highway (Brown and Ross 1994) from an estimated total population of 200 caribou (Smith 2004). A program of active deterrence and monitoring may have reduced collisions in recent years on Highway 40 (Brown and Hobson 1998). However, the reduction in highway mortality may have also been the result of a large component of the A La Peche population essentially abandoning traditional winter range areas and remaining in the mountains during winter (Smith 2004). With increasing road infrastructure in caribou habitat, collisions with vehicles could increase in other areas of the province.

Linear corridors and/or cutblocks may also affect caribou populations by altering the movements and distribution of both predators and prey, and providing easier access for predators to travel within caribou habitats (James and Stuart-Smith 2000). Wolves have been found to occur closer to linear features than expected by chance and to use linear features as travel routes (James 1999, James and Stuart-Smith 2000, Kunkel and Pletscher 2000, Musiani et al. 1998, Neufeld 2006, Whittington et al. 2005; also see Thurber et al. 1994). These features may give wolves greater access to caribou range, especially to areas that were not easily accessible previously via frozen waterways. It also means that linear features are associated with high predation risk for caribou as a result of increased wolf-caribou encounters. James and Stuart-Smith (2000) found that caribou killed by wolves were closer to linear features than were locations of live caribou. Furthermore, wolf use of lines is associated with faster travel (James 1999), which could lead to increased wolf hunting efficiency and kill rates. Based on computer simulation modeling, McCutchen (2007) suggested that increased wolf abundance within caribou ranges is the most likely explanation for caribou declines, and that this increase could result from wolf use of linear features, in effect, artificially inflating wolf numbers.

Caribou in Alberta have been documented to show reduced use of areas adjacent to linear corridors. Distances of reduced use demonstrated by caribou in Alberta depend on season, and on the type and age of the disturbance, but range from 0.1 km to 1.2 km (Dyer et al. 2001, Oberg 2001, Smith et al. 2000; also see Saher 2005). In west-central Alberta, Oberg (2001) found that mountain caribou tended to avoid roads, even those not ploughed during winter; however, caribou did not demonstrate reduced use in relation to seismic lines, possibly because 80% of the seismic lines in the study area were more than 23 years old and forest cover re-growth may have reduced the influence of those seismic lines on caribou behaviour. In another study in west-central Alberta, caribou tended to select areas away from facilities, pipelines, seismic lines and roads during winter (Neufeld 2006), although some seasonal variation occurred. Caribou avoidance of trails has been demonstrated in Jasper National Park (Whittington et al. 2005). Dyer et al. (2001) determined that seismic lines were not barriers to boreal caribou movements; however, roads with moderate vehicle traffic acted as semi-permeable barriers. High levels of above-ground pipeline development in heavy oil production areas will likely significantly affect the ability of caribou to travel within some caribou range areas (Dunne and Quinn 2009, Eide et al. 1986, Smith and Cameron 1985). Weclaw and Hudson (2004) argue that the loss of functional habitat resulting from human infrastructure is the single most detrimental factor negatively affecting woodland caribou.

In Alberta, the areas adjacent to industrial features where caribou demonstrate reduced use are relatively small when compared to those areas in other jurisdictions, a research finding that likely reflects the high density of industrial features in Alberta (i.e., caribou may be less able to space themselves away from industrial features in Alberta because of the abundance of those features). Reindeer and barren-ground caribou in Norway and Alaska show reduced use within 2.5 km to 5 km of linear features (Nellemann and Cameron 1996, Nellemann et al. 2001, Vistnes and Nellemann 2001; review by Cameron et al. 2005). Cameron et al. (1995) found significantly lower abundance and reduced movements of female caribou within a developed oil field compared with more remote areas. In Newfoundland, female caribou show reduced use of areas within 9.2 km of timber harvest cutblocks (Schaefer and Mahoney 2007).

In the case of linear features, functional habitat loss (as a result of caribou reduced use behaviours) is estimated to be much greater than direct habitat loss. For example, Dyer et al. (2001) estimated that during late winter in the West Side of Athabasca River caribou range, 1% of habitat was directly lost to anthropogenic disturbance (predominantly seismic lines) and 48% was functionally lost as a result of reduced use behaviour by caribou. The consequence of direct and indirect habitat loss is that caribou have less available habitat to space themselves away from other prey species and wolves, possibly resulting in effective increases in caribou density and predictability of distribution, and contributing to population declines because of increased susceptibility to predation. For example, in a west-central caribou range, Smith et al. (2000) found that caribou home range size decreased as the area of land with timber harvesting increased. Compression of caribou populations into higher densities (e.g., Nellemann and Cameron 1998, Nellemann et al. 2001, Vistnes and Nellemann 2001) may make individual caribou easier for wolves to find (Dyer et al. 2001, 2002, Smith et al. 2000, Kuzyk et al. 2004). Studies to date for boreal caribou in northern Alberta have failed to demonstrate decreased home range size in response to anthropogenic disturbance, possibly because the disturbance levels were high throughout the studied caribou ranges (Tracz 2005, Tracz et al. in prep.; also see Dalerum et al. 2007).

Sensory disturbance (e.g., noise and activity associated with industrial or recreational activities) may be of concern for caribou ecology in relation to caribou energetics and reduced use of habitats. Caribou in northern Alberta that were exposed to simulated elements of seismic activity showed higher mean movement rates and linear displacement relative to control animals, but feeding patterns were not affected by the disturbance (Bradshaw et al. 1997, Bradshaw et al. 1998). Caribou behavioural responses (displacement/avoidance) have been demonstrated in oilfields in Alaska (Dau and Cameron 1986, Murphy and Curatolo 1987, Nellemann and Cameron 1996). Caribou may become habituated to certain levels of human activity (Cronin et al. 1998), although over two years of study, habituation had not been clearly demonstrated in northern Alberta (Boreal Caribou Research Program unpubl. data).

4. Summary of Habitat Changes Affecting Caribou – Using data from Alberta's woodland caribou populations, both Boutin and Arienti (2008) and Sorenson et al. (2008) demonstrated a highly significant negative relationship between caribou range condition and caribou population growth rate. Sorenson et al. (2008) developed a two-variable model that indicated that 96% of the variation in caribou population growth rates could be explained by amounts of anthropogenic and forest fire-caused habitat alteration on caribou range; caribou lambda (λ) values declined as habitat alteration increased. Similarly, Boutin and Arienti (2008) determined that the density of linear features, together with the amount of young forest (created by timber harvesting and forest fires), was negatively correlated with caribou population growth. Both studies developed equations to describe the negative relationship between lambda (λ) and habitat alteration. In other studies, female adult caribou survival was negatively associated with anthropogenic linear feature density in northern boreal caribou ranges (Dunford 2003) and with cutblock and road density in west-central caribou ranges (Smith 2004).

These results are consistent with research findings in other provinces. For example, in Québec, Courtois et al. (2007) found that caribou were more likely to die as the amount of disturbed habitat (timber harvesting and fire) increased in their range. In British Columbia, Wittmer et al. (2007) found that survival of female mountain caribou declined with the proportion of early and mid-seral stage forests within the home range; higher survival was associated with increasing proportion of older forests. Kinley and Apps (2001) also determined that adult survival was lower in British Columbia ranges with more young forest as a result of timber harvesting, higher road densities, and more fragmentation. More generally, Apps and McLellan (2006) suggested that the persistence of mountain caribou in British Columbia was linked to the presence of old forest and to their isolation from human presence, areas of high road density and motorized access. In Ontario, Schaefer (2003) hypothesized that the northward recession of caribou was driven by the northward advancement of timber harvesting. This was supported by Vors et al. (2007), who found that the probability of caribou persistence was negatively related to the presence of timber harvesting cutblocks. Vors et al. (2007) also recommended that caribou range should be buffered from industrial activities to reduce the likelihood of extirpation.

Environment Canada (2008) recently extended the Sorenson et al. (2008) analysis using boreal ecotype caribou demographic data from across Canada. This work examined the relationship between caribou population parameters and levels of anthropogenic and forest fire disturbance on 24 caribou ranges. Results indicated negative relationships between caribou recruitment rates and total habitat disturbance (i.e., anthropogenic plus fire-caused habitat alteration), and between recruitment rates and only anthropogenic disturbance. There was no significant relationship between recruitment rates and fire disturbance alone.

5. Weather and Climate - Weather may be considered a limiting factor through a complex set of interactions with caribou movements, habitat use, energetics, reproduction and survival, and because it may affect the abundance or distribution of other ungulates and predators. Even though caribou are well adapted to winter, conditions can develop that alter their behaviour, reproduction and survival. Bradshaw et al. (1997) found caribou displacement from simulated elements of seismic activity to be significantly less in a year with deeper snow accumulations, implying that snow depth was affecting caribou behaviour. Also in response to deep or crusted snow, caribou in Alberta have been shown to reduce their daily rate of movement or use dense forest stands (Fish and Wildlife Division unpubl. data, Bjorge 1984, Bradshaw et al. 1995, Fuller and Keith 1981, Morton and Wynes 1997, Schneider et al. 1999, Stuart-Smith et al. 1997). In most years, winter conditions in Alberta are not likely to negatively affect caribou condition, survival or reproduction. However, it is possible that in winters with above-average snowfall and/or severe crusting, caribou condition, reproduction and survival might be compromised. Overwinter reductions in weight are a normal phenomenon in many northern hemisphere ungulates (Clutton-Brock et al. 1982, Adamczewski et al. 1993, Gerhart et al. 1996b). In addition to normal winter stresses, body condition may be further reduced through movements to avoid extensive human activity or through reduced food intake as a result of changes in the abundance or spatial distribution of forages from habitat alteration.

Warming associated with global climate change may alter habitat and caribou population dynamics through increased frequency/severity of forest fires and forest insect outbreaks (such as mountain pine beetle), changes in snow conditions, changes to forage type/quality/abundance, changes in conditions that may increase caribou diseases and parasites, and increased rates of predation of caribou as a result of climate-facilitated increases in the distribution and/or abundance of other prey species and wolves.

STATUS DESIGNATIONS[7]

1. Alberta **-** Under the Government of Alberta general status of wild species process (Alberta Sustainable Resource Development 2007), woodland caribou have been determined to be *At Risk* in the province.

Woodland caribou were initially listed as *Endangered* under the *Wildlife Act* in 1987 (*Threatened* was not available as a classification at that time). In 1997, Alberta's *Wildlife Act* regulations were amended to allow a distinction between *Endangered* and *Threatened* categories – caribou were placed in the *Threatened* category at that time. The *Threatened* status of woodland caribou was reconfirmed in 2001 through the current provincial detailed wildlife status review process; this designation covers both caribou ecotypes occurring in the province.

2. Other Areas **-** The nationally defined Boreal and Southern Mountain woodland caribou populations have been recommended as *Threatened* by the COSEWIC (2009a), and listed as *Threatened* under Canada's *Species at Risk Act* (SARA). Similarly, these caribou are listed as *Threatened* in all provincial/ territorial jurisdictions, with the exception of a *Red Designation* in British Columbia, a pending recommended status of *Threatened* in Saskatchewan, a *Vulnerable* rating in Quebec, and no listing in the Northwest Territories (Table 10). Woodland caribou have been extirpated from New Brunswick, Nova Scotia and Prince Edward Island.

The last remaining woodland caribou in Washington and Idaho (which are part of the Southern Mountain population as defined in Canada) were federally listed as *Endangered* in the United States in 1983 (U. S. Fish and Wildlife Service 1998).

WOODLAND CARIBOU MANAGEMENT IN ALBERTA AND CANADA

A large amount of woodland caribou management planning has occurred in Alberta since the late 1970s. Similarly, management planning related to woodland caribou has intensified in other provinces and territories, and in Canada at a federal level. Key management initiatives are described in the following sections:

1. Provincial Woodland Caribou Management and Planning Initiatives in Alberta **-** Recognition of the need for a provincial woodland caribou management plan began in the late 1970s (Bloomfield 1980b). In response to this recognition, three major provincial strategies were developed. The *Woodland Caribou Provincial Restoration Plan* (Edmonds 1986) and the *Strategy for Conservation of Woodland Caribou in Alberta* (Alberta Fish and Wildlife 1993) were drafted by the Fish and Wildlife Division. No recommendations from these reports were adopted, and the 1993 strategy for conservation document received considerable criticism from government agencies, public groups and industry (Hervieux et al. 1996). Beginning in 1993, a multi-stakeholder committee was formed to identify issues and develop another provincial woodland caribou conservation strategy. In July 1996, the Alberta Woodland Caribou Conservation Strategy Development Committee delivered a report to the provincial Director of Wildlife Management (Alberta Woodland Caribou Conservation Strategy Development Committee 1996). This conservation strategy recommended a decision-making process, identified information needs and management tools, and proposed specific implementation milestones. The goal was to develop a strategy that would result in "healthy caribou populations in perpetuity throughout Alberta's caribou range," including the downlisting of woodland caribou from

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[7] See Appendix 1 for definitions of selected status designations.

Table 10. Legal designations for boreal and southern mountain[1] woodland caribou in Canada.

Jurisdiction	Legal Designation
Government of Canada	Threatened (*Species at Risk Act*) - boreal and southern mountain caribou
British Columbia	Red designation (i.e., flagged as potentially Endangered or Threatened status under BC *Wildlife Act*) – "mountain" caribou as defined in BC, which occupy a portion of the Southern Mountain National Ecological Area, and boreal caribou.
Alberta	Threatened (Alberta *Wildlife Act*) – boreal and southern mountain caribou
Northwest Territories	Not listed – legislation under development (NWT *Species at Risk Act* in force January 2010, boreal caribou listed as Sensitive under NWT General Status Ranks Program)
Saskatchewan	Threatened status recommended (pending in the Saskatchewan *Species at Risk Act* since 2001) – boreal caribou
Manitoba	Threatened (Manitoba *Endangered Species Act*) – boreal caribou
Ontario	Threatened (*Species at Risk in Ontario List*) – boreal caribou
Quebec	Espèce vulnérable (Quebec *Act Respecting Threatened or Vulnerable Species*) – boreal caribou
Newfoundland and Labrador	Threatened (Newfoundland and Labrador *Endangered Species Act*) – boreal caribou in Labrador

[1] See Figure 1; also Environment Canada (2007)

Alberta's Endangered species list. The 1996 conservation strategy was received, but not endorsed, by government.

In September 2001, the Alberta woodland caribou recovery planning process was initiated in response to the reaffirmation of the legal designation of woodland caribou in Alberta as *Threatened* under the provincial *Wildlife Act*. Similarly, COSEWIC (2002) recommended listing the Southern Mountain and Boreal populations of woodland caribou, which includes all woodland caribou found in Alberta, as *Threatened* nationally; the species was subsequently listed in SARA. The *Alberta Woodland Caribou Recovery Plan 2004/05 – 2013/14* (Alberta Woodland Caribou Recovery Team 2005) was completed by a multi-stakeholder recovery team to meet both provincial and national requirements for recovery planning. The completed recovery plan indicated that recovery of woodland caribou in Alberta was biologically and technically feasible. The plan listed two recovery goals: 1) achieve self-sustaining woodland caribou herds and maintain the distribution of caribou in Alberta; and 2) ensure that long-term habitat requirements for woodland caribou are met within Alberta's caribou ranges. The plan recommended specific recovery actions tailored to the population status (i.e., at risk of extirpation, in decline, stable, unknown) of each caribou population in the province. Also, a recommended system of caribou range planning (now termed caribou landscape planning) was advocated. The Alberta government provided qualified approval of the recovery plan in 2005; all provisions of the plan were accepted except for the recommendation that a temporary moratorium on allocation of new resource extraction rights be put in place, until a range-specific management plan was completed, for caribou populations in immediate risk of extirpation.

As recommended in the Alberta recovery plan, woodland caribou landscape planning teams are to be initiated for geographic areas within Alberta (Figure 22). These teams would be managed by, and report to, the multi-stakeholder Alberta Caribou Committee (an advisory committee to the Deputy Minister of Alberta Sustainable Resource Development). The identified task for the landscape teams is to provide landscape-specific caribou conservation and recovery recommendations to the Alberta Caribou Committee, which will then consider and adjust (as needed) the recommendations, and forward them to the Alberta government for consideration. Two caribou landscape planning teams (West-Central and Athabasca) have been formed, and these teams have provided reports to the Alberta Caribou Committee (Alberta Caribou Committee 2008, 2009). The resulting recommendations from the caribou committee have been received by the Alberta Government, but have not been adopted as of July 2010 (Note: Some aspects of the Athabasca Landscape Team findings have been conveyed to the Lower Athabasca Regional Plan initiative, a higher level land-use plan being developed for submission to the Alberta Government for consideration). With the recent advent of regional planning, it is unclear if additional caribou landscape planning teams will be initiated in the province.

Findings included in one or both of the two completed landscape plans, and associated Alberta Caribou Committee recommendations, include the need to:

- adapt, realign, and/or develop government policies and associated regulations to reduce human and industrial footprint on caribou ranges and manage cumulative effects of all activities that impact caribou;
- simultaneously manage all ultimate and proximate factors (e.g., habitat supply and quality, abundance of predators and other prey species) that are affecting caribou populations;
- apply methods to reduce projected industrial footprint;
- establish caribou conservation areas;
- implement coordinated reclamation and restoration of caribou habitat;
- address caribou management considerations at the outset of land-use planning, rather than as conditions on approvals at the end of the process;
- develop more effective mitigation techniques to replace current land-use guidelines, which are not adequate to avoid caribou population declines (recognizing that guidelines alone are not a sufficient tool); and,
- adopt and implement a concept of caribou habitat intactness, to protect and improve habitat conditions on caribou ranges.

2. Regional Caribou Management Initiatives in Alberta - In the 1980s, concerns about a lack of caribou conservation measures together with increasing confrontations between government regulators and industrial operators resulted in the establishment of local or regional multi-stakeholder committees. Creation of these committees was facilitated by provincial government information (policy) letter (IL #91-17), which stated "…industrial activity could occur on caribou range provided that the integrity and supply of habitat is maintained to permit its use by caribou." (Alberta Energy 1991, 1994, 1996).

Although IL #91-17 dealt primarily with the petroleum and natural gas industry, the letter was adopted by the committees for application to all industries operating on caribou range. The approach to managing land-use activities improved working relationships in many cases and helped to establish caribou research programs (Dzus and Boutin 1998, Hamilton and Edey 1998, Rippin et al. 1996), with a goal

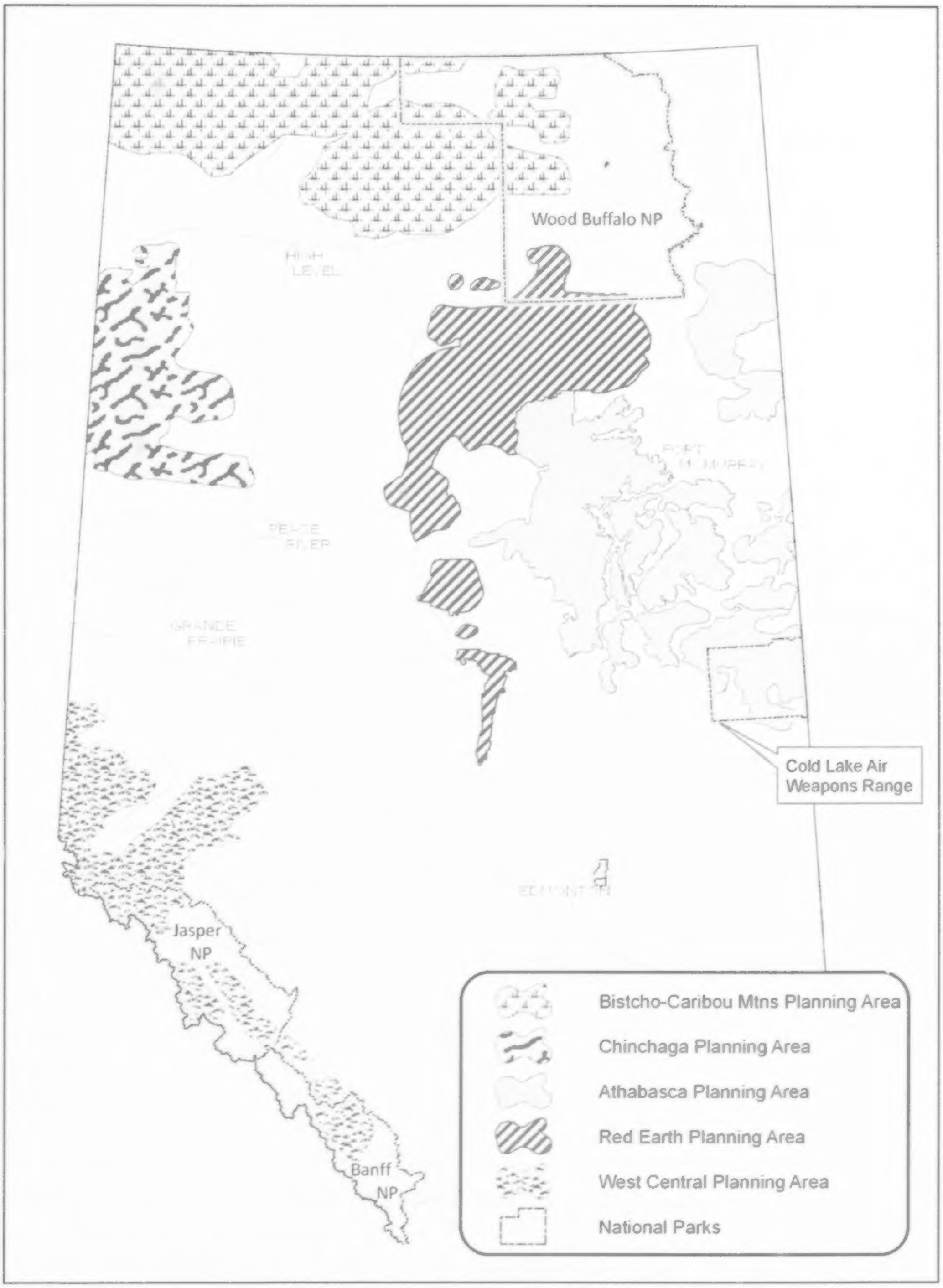

Figure 22. Location of caribou landscape planning areas in Alberta. Planning area boundaries were developed by Alberta Sustainable Resource Development, in response to recommendations in Alberta Woodland Caribou Recovery Team (2005).

to establish knowledge-based management plans and industrial guidelines that will allow caribou conservation and resource extraction on the same land base. Although benefits were accrued by all participants (Edey et al. 1998), all caribou-related industry land-use guidelines continued to be challenged annually by various stakeholders.

The local and regional multi-stakeholder committees developed various operating guidelines to guide industrial activities on provincially managed caribou ranges (Alberta Energy 1994, 1996, 2003, Boreal Caribou Committee 2001, West-central Alberta Caribou Standing Committee 1996). Caribou-related industrial development guidelines are currently applied in just portions of, or throughout, individual caribou ranges within the province (Figure 23). In general, these guidelines focus on minimizing the size and life-span of individual industrial developments, including the use of temporary or low-grade access routes where practical. However, operating guidelines have not been applied consistently by government and industry across the province (D. Hervieux pers. comm.), and as a result the construction and management of industrial features within caribou range varies considerably at provincial and, in some cases, regional scales. Current guidelines attempt to reduce the negative effects of development on caribou populations and habitat at the level of individual projects, and thereby minimize the cumulative effects of overall infrastructure development; guidelines have essentially been used in lieu of broader landscape level management (Alberta Woodland Caribou Recovery Team 2005). Current project-level land-use guidelines for industrial activities on caribou range in northern Alberta were demonstrated to be ineffective, as a sole tool, in terms of providing for long-term caribou conservation (Boreal Caribou Research Program 1999b). This inadequacy of current guidelines has been corroborated and documented by modeling results from caribou landscape plans (Alberta Caribou Committee 2008, 2009).

In 2005, all local and regional multi-stakeholder committees, as well as the Alberta Woodland Caribou Recovery Team, were disbanded and replaced by the Alberta Caribou Committee, which provides advice to government on caribou conservation and recovery.

3. Woodland Caribou Management and Planning Initiatives in other Provinces and Territories and Federally in Canada - Most provinces and territories in Canada have now completed woodland caribou recovery plans or strategies for threatened woodland caribou within their jurisdictions. These documents are similar in content to the Alberta woodland caribou recovery plan. The jurisdictional documents formed the basis for the development of a national boreal caribou recovery strategy in Canada. A national team composed of representatives from Environment Canada, Parks Canada Agency, and all affected provinces and territories completed a draft recovery strategy for boreal ecotype caribou in Canada (Environment Canada 2007). The completed recovery strategy indicated that recovery of boreal ecotype caribou in Canada was biologically and technically feasible. This strategy was submitted to Environment Canada; however, the federal government has not adopted the strategy and has indicated that a new recovery strategy for boreal caribou will be developed by 2011.

Following receipt of the draft national recovery strategy for boreal caribou in 2007, Environment Canada formed an expert panel on the identification of critical habitat (as defined under the federal *Species at Risk Act*) for boreal caribou in Canada. This panel completed a report (Environment Canada 2008) that, in addition to other elements, recommended equating critical habitat (as defined under the *Species at Risk Act*) with caribou ranges. The group also developed a procedure to assess the probability that current conditions (related to caribou population trend and size, and levels of habitat disturbance from anthropogenic

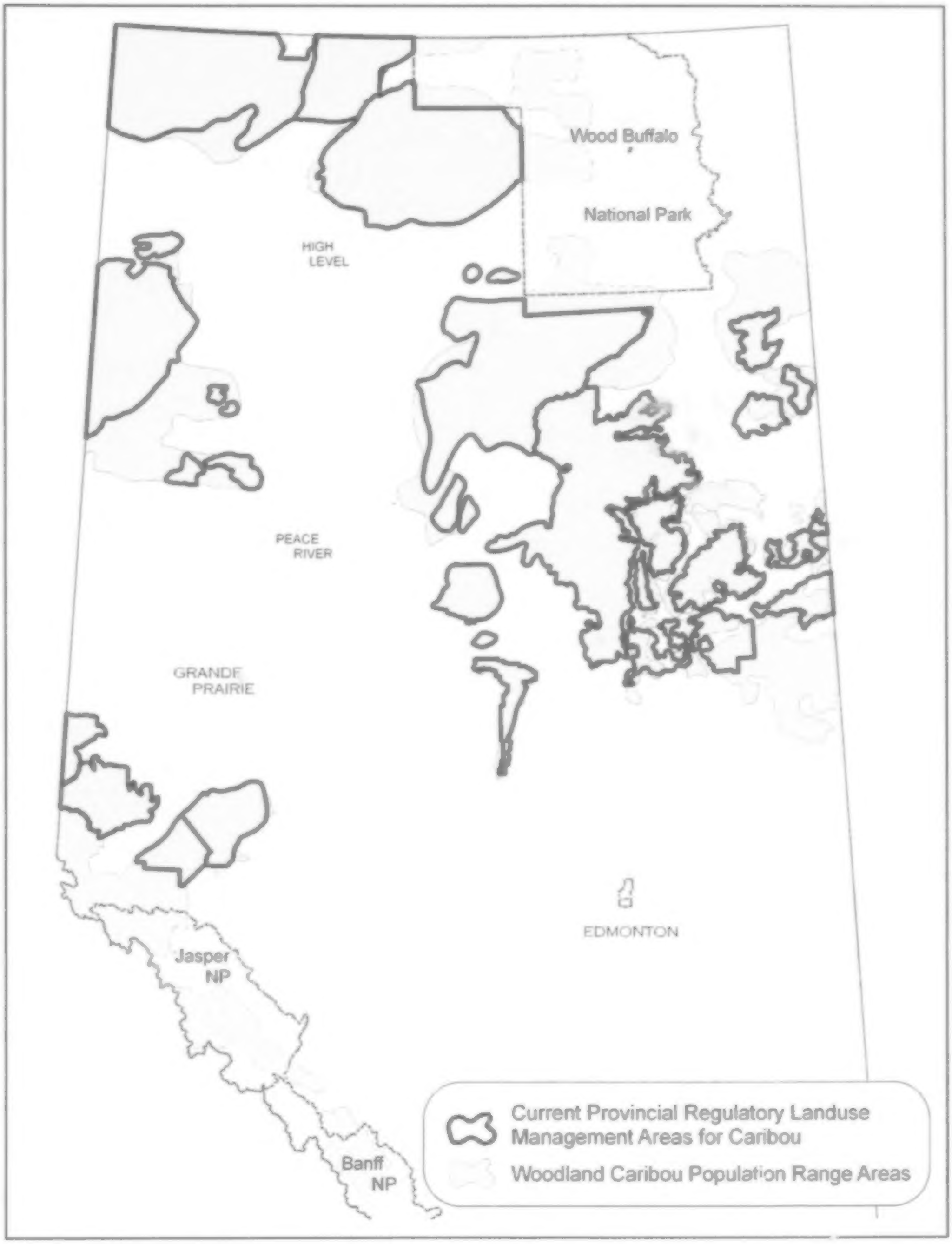
Wood Buffalo
National Park
HIGH LEVEL
PEACE RIVER
GRANDE PRAIRIE
EDMONTON
Jasper NP
Banff NP
Current Provincial Regulatory Landuse Management Areas for Caribou
Woodland Caribou Population Range Areas

Figure 23. Government of Alberta regulatory land-use management areas for caribou in comparison to woodland caribou range areas.

activities and forest fire) on each boreal caribou range in Canada will support a self-sustaining caribou population; a summary national-level map of the resulting analysis was prepared. The panel report also provided modeling results describing how even relatively small boreal caribou populations could have a reasonable probability of persistence, under favourable demographic conditions. Environment Canada is currently consulting with stakeholders nationally on the topic of critical habitat for boreal caribou.

Environment Canada is also responsible for forming a multi-jurisdictional team to prepare a national recovery strategy for the *Threatened* southern mountain woodland caribou population, but has yet to do so.

SYNTHESIS

Woodland caribou were designated as a *Threatened* species in Alberta as a result of reductions in distribution, declines in the number and size of populations, and the threat of further population and distribution declines associated with human activities. Although population dynamics often exhibit annual variation in survival of adults and juveniles, most caribou populations in Alberta are now demonstrating a pattern of sustained population decline. Evidence supports the conclusion that caribou population declines in Alberta are a result of the direct and indirect effects of increases in the amount and extent of industrial and other human activities on and near caribou ranges, combined in some cases with the extent of recent forest fires.

Conserving and improving the amount and quality of habitat for caribou populations is an obvious challenge. Resource extraction activities have the potential to significantly reduce or eliminate many caribou populations in Alberta. The challenge is to maintain sufficient quantities of suitable habitat through time within caribou ranges. As recommended by the Alberta Woodland Caribou Recovery Team (2005), and documented with analyses in the two available caribou landscape plans, it will be necessary to manage excessive predation pressure on some caribou populations in order to avoid extirpation of caribou populations, as management actions are taken to improve currently unfavourable habitat conditions. The recovery of *Threatened* woodland caribou has been determined to be technically and biologically feasible, both in Alberta and Canada.

Research completed in Alberta and elsewhere has dramatically increased our knowledge of caribou ecology. However, research alone will not ensure the continuation of Alberta's caribou populations; improvements will be needed to both government policy and procedures and industry business practices. Improvements should include the following: assessment and management of cumulative effects as they affect caribou, identification and provision of adequate habitat (amount and type) to allow for caribou persistence, coordinated planning, restoration of old industrial land-use features, and appropriate management of wolves and other prey species.

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Appendix 1. Definitions of status ranks and legal designations.

A. The General Status of Alberta Wild Species 2005 (after Alberta Sustainable Resource Development 2007)

2005 Rank	**1996 Rank**	**Definitions**
At Risk	Red	Any species known to be *At Risk* after formal detailed status assessment and designation as *Endangered* or *Threatened* in Alberta.
May Be At Risk	Blue	Any species that may be at risk of extinction or extirpation, and is therefore a candidate for detailed risk assessment.
Sensitive	Yellow	Any species that is not at risk of extinction or extirpation but may require special attention or protection to prevent it from becoming at risk.
Secure	Green	Any species that is not *At Risk, May Be At Risk* or *Sensitive*.
Undetermined	Status Undetermined	Any species for which insufficient information, knowledge or data is available to reliably evaluate its general status.
Not Assessed	n/a	Any species that has not been examined during this exercise.
Exotic/Alien	n/a	Any species that has been introduced as a result of human activities.
Extirpated/Extinct	n/a	Any species no longer thought to be present in Alberta (Extirpated) or no longer believed to be present anywhere in the world (Extinct).
Accidental/Vagrant	n/a	Any species occurring infrequently and unpredictably in Alberta, i.e., outside its usual range.

B. Alberta Species at Risk Formal Status Designations

Species designated as *Endangered* under Alberta's *Wildlife Act* include those listed as *Endangered* or *Threatened* in the Wildlife Regulation (in bold).

Endangered	**A species facing imminent extirpation or extinction.**
Threatened	**A species likely to become endangered if limiting factors are not reversed.**
Species of Special Concern	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Data Deficient	A species for which there is insufficient scientific information to support status designation.

C. Committee on the Status of Endangered Wildlife in Canada (after COSEWIC 2009b)

Extinct	A species that no longer exists.
Extirpated	A species that no longer exists in the wild in Canada, but occurs elsewhere.
Endangered	A species facing imminent extirpation or extinction.
Threatened	A species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction.
Special Concern	A species that may become threatened or endangered because of a combination of biological characteristics and identified threats.
Not at Risk	A species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient	A category that applies when the available information is insufficient to (a) resolve a wildlife species' eligibility for assessment, or (b) permit an assessment of the wildlife species' risk of extinction.

Appendix 1 continued:

D. Heritage Status Ranks: Global (G), National (N), Subnational (S) (after Alberta Natural Heritage Information Centre 2007, NatureServe 2009)

G1/N1/S1	5 or fewer occurrences or only a few remaining individuals. May be especially vulnerable to extirpation because of some factor of its biology.
G2/N2/S2	6 to 20 or fewer occurrences or with many individuals in fewer locations. May be especially vulnerable to extirpation because of some factor of its biology.
G3/N3/S3	21 to 100 occurrences; may be rare and local throughout its range, or in a restricted range (may be abundant in some locations). May be susceptible to extirpation because of large-scale disturbances.
G4/N4/S4	Typically > 100 occurrences. Apparently secure.
G5/N5/S5	Typically > 100 occurrences. Demonstrably secure.
GX/NX/SX	Believed to be extinct or extirpated; historical records only.
GH/NH/SH	Historically known; may be relocated in the future.
G?/N?/S?	Not yet ranked, or rank tentatively assigned.

E. United States Endangered Species Act (after National Research Council 1995)

Endangered	Any species that is in danger of extinction throughout all or a significant portion of its range.
Threatened	Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Appendix 2. Total number of woodland caribou observed (classified) during annual late-winter (February/March) population composition surveys in Alberta[1] (1993 – 2009). NA = records not currently available.

Population	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09
West Side Athabasca River	NA	NA	175	160	199	185	178	177	141	117	113	97	84	125	130	129
East Side Athabasca River	NA	147	179	113		109	138	110	167	118	107	121	97	108	116	139
Yates															139	336
Red Earth		90	166	112	NA	98	135	131	105	131	106	85	89	128	110	141
Caribou Mountain		158	173	159	267	205	137	202	183	173	NA	314	90	272	119	311
Bistcho													NA	NA	292	148
Cold Lake (combined AB&SK)[2]						263	202	260	257	NA	213	NA	157	137	214	216
Cold Lake (AB)						158	116	149	145	NA	136	83	88	42	87	110
Cold (SK)						95	86	111	112		77		69	95	127	106
Chinchaga									55	86	NA	109	153	156	177	221
Slave Lake & Nipisi (combined)[3]									52	44	35	44	63	86	86	108
Richardson																92
Little Smoky						42	43	44	49	74	60	46	23	55	67	62
Redrock-Prairie Creek						63	52	NA	132	121	94	68	108	91	79	141
A La Peche					99	147	116	145	NA	95	92	94	63	71	81	99
Narraway													40	87	109	86
Jasper											36	35	54	76	66	51

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[1] In some cases, includes animals observed in British Columbia, Northwest Territories, or Saskatchewan for some cross-jurisdictional boundary populations.

[2] Data have been collected separately for segments of this population occurring on the Saskatchewan (SK) and Alberta (AB) portions of the Cold Lake range, in an attempt to compare caribou vital rates for parts of the range that initially had higher (AB) and lower (SK) levels of industrial development.

[3] Combined data have been collected for these populations, owing to the initial (incorrect) belief that only a single population was present on the two range areas.

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